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REDACTED VERSION

ICF TECHNOLOGY INCORPORATED

TO: Stacey Bennett, WAM, EPA Region 6

THRU: Marta Green, MK-Environmental Services

THRU: Debra Pandak, ICF Technology, Inc.

FROM: Kristine Lloyd, Task Manager, ICF Technology, Inc.

DATE: October 19, 1993

REF: ARCS Contract No. 68-W9-0025
Work Assignment No. 35-6JZZ

SUBJ: Site Inspection Prioritization
Pine Bluff Arsenal, Pine Bluff, Jefferson County, Arkansas
CERCLIS #AR0213370707

INTRODUCTION

The U.S. EPA Region 6 has tasked the Alternative Remedial Contracting Strategy (ARCS) team, MK-Environmental Services and ICF Technology, Inc. (MK/ICF), to complete a Site Inspection Prioritization (SIP) package for Pine Bluff Arsenal located in Pine Bluff, Jefferson County, Arkansas. The objectives of the SIP are to generate a PREscore package with available data and to determine the data gaps that would greatly influence the site score so a decision can be made as to the status of the site.

SITE HISTORY AND DESCRIPTION

The Pine Bluff Arsenal (PBA) is located in the central portion of Jefferson County, approximately 8 miles north of Pine Bluff and 30 miles southeast of Little Rock. The site contains 23 potential sources; the source that was evaluated for this SIP is located at 34°20'22" latitude and 92°03'54" west longitude (Figure 1). PBA lies on the west side of the Arkansas River and is 120 miles upstream from its junction with the Mississippi River.

PBA occupies 14,454 acres, including easements for railroad and natural gas distribution line right-of-ways. Construction of PBA began in December 1941 for manufacturing, loading and assembling of incendiary and chemical munitions, storage magazines, laboratories and other associated administrative and logistical support facilities. Originally, activities at the PBA involved the loading of magnesium and thermal type bombs. Expansion through the years included the manufacture of chemical and biological agents and the filling of chemical bombs and munitions, including smoke munitions, with chlorine, mustard and lewisite.

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During the Korean War, PBA produced incendiary bombs, clusters, smoke grenades, smoke pots, canisters, white phosphorous and FS shells (sulfur trioxide-chlorosulfaric acid solutions). Biological warfare operations were started in 1953 and lasted until 1969. The demilitarization of all inventories of antipersonnel biological agents and munitions was completed in January 1972.

SIP OVERVIEW

There are 23 sources within PBA where hazardous wastes are known to exist (Table 1). The Mustard Burn Pit or Mustard Dump Yard was chosen to evaluate the PBA as it poses the greatest concern because of the contaminants detected, the hazardous waste quantity, the proximity of the Arkansas River and the available data regarding this source.

Using the available file data, it has been determined that the PREscore package for the Pine Bluff Arsenal does not exceed the minimum score necessary for placement on the National Priorities List. Contributing factors to the low score at PBA are the lack of ground water targets in the Alluvial Aquifer and the lack of an observed release in the Alluvial Aquifer. Additional contributing factors are the low population within the target distance limits from PBA and the lack of observed releases in the surface water and air migration pathways.

Source Waste Characterization

As stated previously, numerous sources exist within the PBA. The source evaluated for the PREscore package was the Mustard Burn Pits which was chosen after a cursory review of all the sources at PBA. The Mustard Burn Pits (also referred to as Source 12) cover 25 acres. These burn pits were primarily used as a burn and disposal area for mustard munitions for approximately 6 years in the 1940s. Contaminants detected at this source include arsenic, barium, chromium, lead and mustard by-products. This source was evaluated as a landfill in the PREscore as wastes were disposed into trenches then later backfilled. Four parallel trenches on the southern end of the site contain rusted munitions and 55-gallon drums. A larger pile of debris exists west of the four trenches where shell casings were stacked and burned with thermite. A smaller pile is present south of the four trenches. A large burning area located in the central portion of the site covered approximately 1 acre. Pits on the northern end of the site contain the remnants of tubes which held igniter mix for the munitions. A smaller burn area in the northern portion of this source covers approximately 10,000 square feet (Ref. 13, Figure 5-1).

There is currently no evidence to indicate that this source was lined. The site is located in the 100-year floodplain of the Arkansas River and is not controlled for flooding.

Ground Water Pathway

PBA is underlain by two aquifers, the Quaternary sands and gravels of the alluvium and the deeper Tertiary Sparta Sand. The alluvium is less than 50 feet deep and is used for rural domestic purposes, farm irrigation and fish farming. There are no documented alluvial wells within the 4-mile radius; however, the possibility exists that there are wells within the target distance limit.

TABLE 1

POTENTIAL HAZARDOUS WASTE SOURCE AREAS AT PINE BLUFF ARSENAL

Source Area Number	Source Area Name
2	Webster Road Test Site
4a	504 Street Burn site
7a	Toxic Storage Yard
7b	Lewisite Disposal Site
7c	Mustard Burn Pits
7d	TSY Borrow Pits
10	Depot Burning and Demolition Area
12	Abandoned Mustard Burning Pits
13a	Abandoned Burn Pits
16a	White Phosphorus Setting Pond
17	Product Assurance Test Range and Dump Site
20a	Depot South Burn Pit
20b	White Phosphorus Slag Burn Pit
23a	White Smoke Test Pond and Dump Site
24	Termite Waste Disposal Site
26	Quality Assurance Drop Test Tower
27	Agent BZ Pond
29	Solid Waste Site
29a	Salt Pile 54-120
31a	Product Assurance Test Site
31b	Standby Grenade Test Basin
34	NCTR Equalization Pool
38	Impregnite Sludge Lagoon

Monitoring wells were installed in the alluvium at the Mustard Burn Pits in 1982. An observed release could not be established because the downgradient concentrations of arsenic, barium, chromium and lead were not detected at levels at least three times the background well.

The Sparta Sand supplies water to the PBA and the City of Pine Bluff. The 8 arsenal wells are 800 to 1,000 feet deep and serve approximately 982 workers. The wells are located within 3 miles of the source. The City of Pine Bluff wells are not located within the 4-mile radius of this source. There is a possibility that other wells in the Sparta Sand exist within the 4-mile radius.

Surface Water Pathway

Surface water from the site flows into the Arkansas River, which is approximately 100 feet to the east and is the Probable Point-of-Entry (PPE). The end of the 15-mile downstream target distance limit is in the Arkansas River.

The Arkansas River is used for fishing, boating and swimming. It has an average flow rate of 52,324 cubic feet per second. It is not known if there are any drinking water or irrigation intakes within the target distance limit. The pounds of fish caught and consumed annually is not known. There are approximately 4 miles of wetland frontage along the Arkansas River. It is not known if there are any other sensitive environments within the 15-mile target distance limit.

No surface water samples have been collected from the PPE or in the Arkansas River; therefore, an observed release to the surface water pathway cannot be established.

Soil Exposure Pathway

It was estimated in the Closure Report for the Mustard Burn Pit that there are approximately four acres or 174,240 square feet of contaminated soil. The majority of the soil was from burned residue from the various types of disposal operations.

There is no documentation to indicate that there are residences, daycare centers or schools within 200 feet of the site. According to the U.S. EPA Geographical Exposure Modeling System and the U.S.G.S. 7.5 series topographical maps, there are no residences within 2 miles of the site.

Air Pathway

Air samples have not been collected from the Mustard Burn Pits; therefore, an observed release to the air pathway cannot be established. The population within the 4-mile radius is 1,088. The nearest regularly occupied building is approximately 1,200 feet from the Mustard Burn Pit. Federal endangered species have been reported on PBA (Mississippi Red Wolf, Peregrin Falcon and Red-cockaded Woodpecker) and 30 acres of wetlands are present on PBA. It is not known if there are sensitive environments located on the source area.

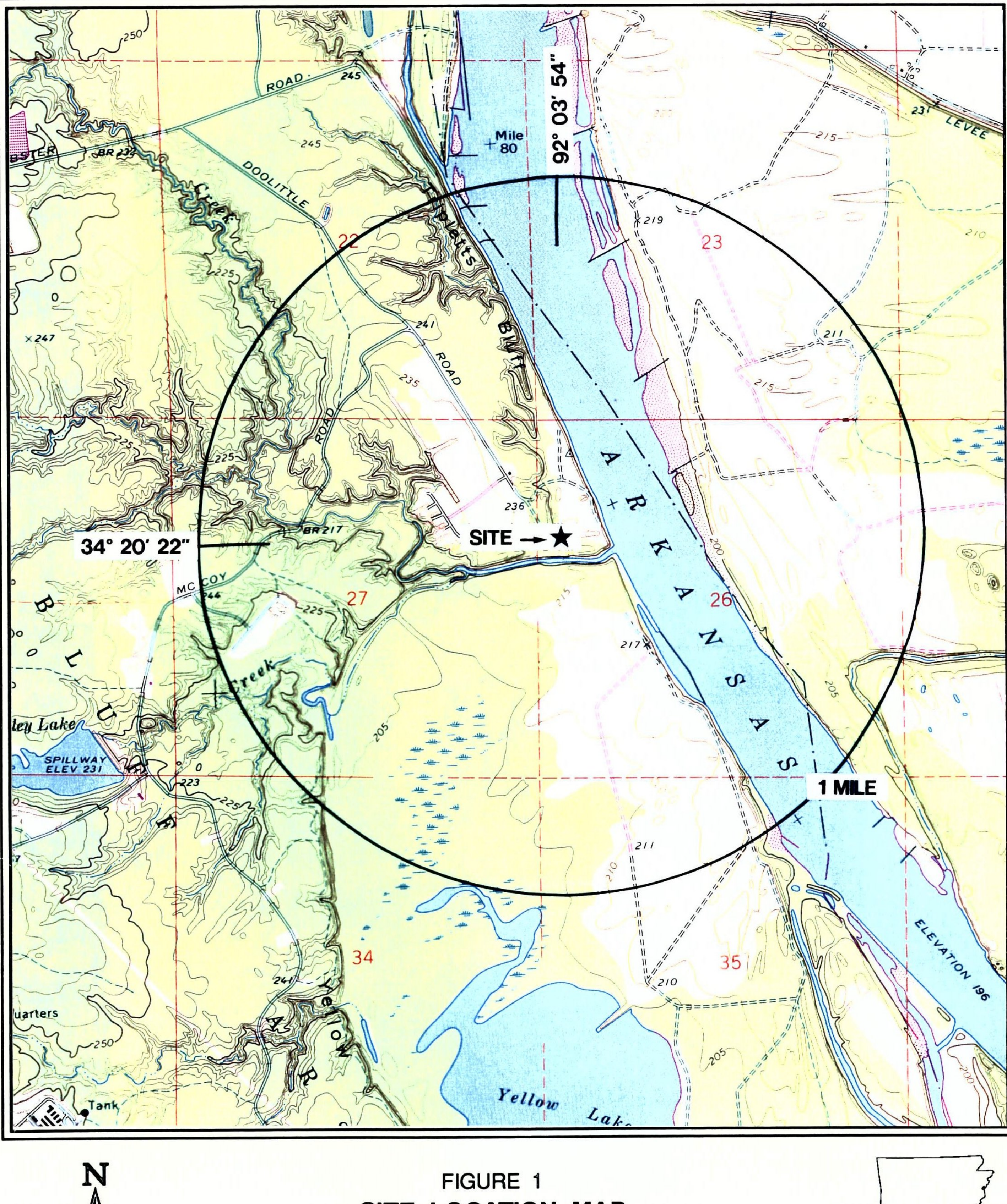
DATA GAPS

The following data gaps were identified within the evaluation of the PREscore package:

- Alluvial ground water targets within the 4-mile target radius;
- Additional Sparta Sand ground water targets within the 4-mile target radius;
- Wellhead Protection Areas in the Pine Bluff area;
- Presence or absence of surface water intakes within the 15-mile target distance limit of the Arkansas River;
- Exact location of endangered species on PBA;
- The exact pounds of human chain food organisms caught and consumed annually from the Arkansas River;
- Current number of employees at PBA;
- Analytical data to establish whether an observed release has occurred to any of the migration pathways;
- Exact depth soil samples were collected; and
- Confirmation of sensitive environments within the target distance.

ICF TECHNOLOGY INCORPORATED

PREPARED BY	DRAWN BY	REVIEWED BY	APPROVED BY	CAD FILE	PROJECT NUMBER
KL	GCH			CO552	37637-085-01



0 2000

SCALE 1 : 24000

FIGURE 1

SITE LOCATION MAP

PINE BLUFF ARSENAL
PINE BLUFF, ARKANSAS.

CERCLIS # AR0213820707

QUADRANGLE LOCATION
WHITE HALL, ARK. 1970
PHOTOREVISED 1984

PRESCORE DOCUMENTATION LOG SHEET

SITE: PINE BLUFF ARSENAL

IDENTIFICATION NUMBER: ID #AR0213370707

CITY: PINE BLUFF

STATE: ARKANSAS

REFERENCE NUMBER	DESCRIPTION OF THE REFERENCE
1	U.S. Environmental Protection Agency. Final Rule Hazard Ranking system. FR515312-51667. December 14, 1992.
2	Superfund Chemical Data Matrix. Appendices B-1, B-2 and C. March 1993.
3	U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Office of Emergency and Remedial Response, Hazardous Site Evaluation Division. "PREScore Software User's Manual and Tutorial", Version 1.0. Publication No. 9345.1-04. September 1991.
4	Installation Assessment of Pine Bluff Arsenal, Pine Bluff, Arkansas. Records Evaluation Report No. 113. August 1977.
5	Pine Bluff Arsenal, Hazardous Landfill/Closure Sites, Concept Design Analysis. U.S. Army Corps of Engineers, Volume 2 - Attachments A through F. August 1984.
6	EPA Form T2070-3, Site Inspection Report of Pine Bluff Arsenal. AR710, Pine Bluff Arkansas. Prepared by Thomas Smith, Geologist, Ecology & Environment, Inc. March 2, 1982.
7	Broughton, G. D., Hydrogeological Survey of Pine Bluff Arsenal. U.S. Army Engineers. Watercamp Experiment Station. August 1980.
8	Letter. Annual Net Precipitation. To: Lacy Sibold, U.S. EPA. From: Andrew M. Platt, Group Leader, The MITRE Corporation. May 26, 1988.
9	Various Well Logs, Pine Bluff Arsenal.
10	Hershfield, D. M., Rainfall Frequency Atlas of the United States. U.S. Weather Bureau Technical Paper No. 40.

PRESCORE DOCUMENTATION LOG SHEET

Continued

REFERENCE NUMBER	DESCRIPTION OF THE REFERENCE
11	U.S.G.S. 7.5 Series Topographical Maps. Reafield, AR; Wright, AR; Sherrill, AR; Hardin, AR; Whitehall, AR; Rob Roy, AR; Pine Bluff, AR; Ladd, AR, 1962. Photorevised 1971 and 1975.
12	Arkansas Water Resources Data. U.S. Geological Survey Water Data Report AR-90-1. 1990.
13	Site Closure Plan, Site 12, Mustard Burn Pits, Pine Bluff Arsenal, U.S. Army Corps of Engineers, Tulsa District. July 1985.
14	Regulation Establishing Water Quality Standards for Surface Waters of Arkansas. State of Arkansas, Department of Pollution Control and Ecology, Regulation No. 2 As Amended. January 1988.
15	U.S. Environmental Protection Agency Geographical Exposure Modeling System. Accessed June 4, 1993 by Kevin Jaynes.
16	RCRA Facility Assessment Evaluation, Prepared by A. T. Kearney Centaur for EPA Region 6, Technical Compliance Section. July 16, 1987.

Record Information

1. Site Name: US Army Pine Bluff Arsenal
   (as entered in CERCLIS)

2. Site CERCLIS Number: AR0213320707

3. Site Reviewer: Kristine Lloyd, ICF Technology Inc.

4. Date: October 8, 1993

5. Site Location: Pine Bluff/Jefferson County, Arkansas
   (City/County,State)

6. Congressional District: 4

7. Site Coordinates: Single

   Latitude: 34°20'22. Longitude: 092°03'54.

Site Description

1. Setting: Rural

2. Current Owner: Federal

3. Current Site Status: Active

4. Years of Operation: Active Site , from and to dates: 1941 to present

5. How Initially Identified: Other Federal Program

6. Entity Responsible for Waste Generation:

   - Federal Facility
     - Military

7. Site Activities/Waste Deposition:

   - Surface Impoundment
   - Waste Piles
   - Industrial Landfill
   - Drum/Container Storage
   - Discharge to Sewer/Surface Water
   - Airborne Release/Incineration

Waste Description

8. Wastes Deposited or Detected Onsite:

- Organic Chemicals
- Inorganic Chemicals
- Solvents
- Acids/Bases
- Explosives
- Pesticides/Herbicides
- Metals
- Construction Waste
- Lead
- PCBs

Response Actions

9. Response/Removal Actions:

- Other Removal Action Has Occurred
- Other Emergency Action Has Occurred

RCRA Information

10. For All Active Facilities, RCRA Site Status:

- Other - Site Closure Plan for var

Demographic Information

11. Workers Present Onsite: Yes

12. Distance to Nearest Non-Worker Individual: > 1 Mile

13. Residential Population Within 1 Mile: No

14. Residential Population Within 4 Miles: 1088.0

Water Use Information

15. Local Drinking Water Supply Source:

    - Ground Water (within 4 mile distance limit)

16. Total Population Served by Local Drinking Water Supply Source: Unknown

17. Drinking Water Supply System Type for Local Drinking Water Supply Sources:

    - Municipal (Services over 25 People)

18. Surface Water Adjacent to/Draining Site:

    - River

HRS DOCUMENTATION RECORD

US Army Pine Bluff Arsenal - 10/18/93

1. Site Name: US Army Pine Bluff Arsenal
   (as entered in CERCLIS)

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   (City/County,State)

6. Congressional District: 4

7. Site Coordinates: Single

   Latitude: 34°20'22. Longitude: 092°03'54.

	Score
Ground Water Migration Pathway Score (Sgw)	0.27
Surface Water Migration Pathway Score (Ssw)	0.50
Soil Exposure Pathway Score (Ss)	1.20
Air Migration Pathway Score (Sa)	0.68

Site Score	0.75

NOTE

EPA uses the terms "facility," "site," and "release" interchangeably. The term "facility" is broadly defined in CERCLA to include any area where hazardous substances have "come to be located" (CERCLA Section 109(9)), and the listing process is not intended to define or reflect boundaries of such facilities or releases. Site names, and references to specific parcels or properties, are provided for general identification purposes only. Knowledge regarding the extent of sites will be refined as more information is developed during the RI/FS and even during implementation of the remedy.

GROUND WATER MIGRATION PATHWAY SCORESHEET
US Army Pine Bluff Arsenal - 10/18/93

GROUND WATER MIGRATION PATHWAY Factor Categories & Factors	Maximum Value	Value Assigned
Likelihood of Release to an Aquifer Aquifer: Sparta Sand		
1. Observed Release	550	0
2. Potential to Release		
2a. Containment	10	10
2b. Net Precipitation	10	6
2c. Depth to Aquifer	5	1
2d. Travel Time	35	5
2e. Potential to Release [lines 2a(2b+2c+2d)]	500	120
3. Likelihood of Release	550	120
Waste Characteristics		
4. Toxicity/Mobility	*	1.00E+02
5. Hazardous Waste Quantity	*	10
6. Waste Characteristics	100	6
Targets		
7. Nearest Well	50	5.00E+00
8. Population		
8a. Level I Concentrations	**	0.00E+00
8b. Level II Concentrations	**	0.00E+00
8c. Potential Contamination	**	1.60E+01
8d. Population (lines 8a+8b+8c)	**	1.60E+01
9. Resources	5	5.00E+00
10. Wellhead Protection Area	20	5.00E+00
11. Targets (lines 7+8d+9+10)	**	3.10E+01
12. Targets (including overlaying aquifers)	**	3.10E+01
13. Aquifer Score	100	0.27
GROUND WATER MIGRATION PATHWAY SCORE (Sgw)	100	0.27

* Maximum value applies to waste characteristics category.
** Maximum value not applicable.

SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORESHEET

US Army Pine Bluff Arsenal - 10/18/93

SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT Factor Categories & Factors DRINKING WATER THREAT	Maximum Value	Value Assigned
Likelihood of Release		
1. Observed Release	550	0
2. Potential to Release by Overland Flow		
2a. Containment	10	10
2b. Runoff	25	1
2c. Distance to Surface Water	25	20
2d. Potential to Release by Overland Flow [lines 2a(2b+2c)]	500	210
3. Potential to Release by Flood		
3a. Containment (Flood)	10	10
3b. Flood Frequency	50	25
3c. Potential to Release by Flood (lines 3a x 3b)	500	250
4. Potential to Release (lines 2d+3c)	500	460
5. Likelihood of Release	550	460
Waste Characteristics		
6. Toxicity/Persistence	*	1.00E+04
7. Hazardous Waste Quantity	*	10
8. Waste Characteristics	100	18
Targets		
9. Nearest Intake	50	0.00E+00
10. Population		
10a. Level I Concentrations	**	0.00E+00
10b. Level II Concentrations	**	0.00E+00
10c. Potential Contamination	**	0.00E+00
10d. Population (lines 10a+10b+10c)	**	0.00E+00
11. Resources	5	5.00E+00
12. Targets (lines 9+10d+11)	**	5.00E+00
13. DRINKING WATER THREAT SCORE	100	0.50

* Maximum value applies to waste characteristics category.
** Maximum value not applicable.

SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORESHEET

US Army Pine Bluff Arsenal - 10/18/93

SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT Factor Categories & Factors HUMAN FOOD CHAIN THREAT	Maximum Value	Value Assigned
Likelihood of Release		
14. Likelihood of Release (same as line 5)	550	460
Waste Characteristics		
15. Toxicity/Persistence/Bioaccumulation	*	5.00E+05
16. Hazardous Waste Quantity	*	10
17. Waste Characteristics	1000	32
Targets		
18. Food Chain Individual	50	0.00E+00
19. Population		
19a. Level I Concentrations	**	0.00E+00
19b. Level II Concentrations	**	0.00E+00
19c. Pot. Human Food Chain Contamination	**	3.00E-06
19d. Population (lines 19a+19b+19c)	**	3.00E-06
20. Targets (lines 18+19d)	**	3.00E-06
21. HUMAN FOOD CHAIN THREAT SCORE	100	0.00

* Maximum value applies to waste characteristics category.
** Maximum value not applicable.

SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORESHEET

US Army Pine Bluff Arsenal - 10/18/93

SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT Factor Categories & Factors ENVIRONMENTAL THREAT	Maximum Value	Value Assigned
Likelihood of Release		
22. Likelihood of Release (same as line 5)	550	460
Waste Characteristics		
23. Ecosystem Toxicity/Persistence/Bioacc.	*	5.00E+06
24. Hazardous Waste Quantity	*	10
25. Waste Characteristics	1000	56
Targets		
26. Sensitive Environments		
26a. Level I Concentrations	**	0.00E+00
26b. Level II Concentrations	**	0.00E+00
26c. Potential Contamination	**	1.00E-03
26d. Sensitive Environments (lines 26a+26b+26c)	**	1.00E-03
27. Targets (line 26d)	**	1.00E-03
28. ENVIRONMENTAL THREAT SCORE	60	0.00
29. WATERSHED SCORE	100	0.50
30. SW: OVERLAND/FLOOD COMPONENT SCORE (Sof)	100	0.50

* Maximum value applies to waste characteristics category.

** Maximum value not applicable.

SOIL EXPOSURE PATHWAY SCORESHEET

US Army Pine Bluff Arsenal - 10/18/93

SOIL EXPOSURE PATHWAY Factor Categories & Factors RESIDENT POPULATION THREAT	Maximum Value	Value Assigned
Likelihood of Exposure		
1. Likelihood of Exposure	550	550
Waste Characteristics		
2. Toxicity	*	1.00E+04
3. Hazardous Waste Quantity	*	10
4. Waste Characteristics	100	18
Targets		
5. Resident Individual	50	0.00E+00
6. Resident Population		
6a. Level I Concentrations	**	0.00E+00
6b. Level II Concentrations	**	0.00E+00
6c. Resident Population (lines 6a+6b)	**	0.00E+00
7. Workers	15	1.00E+01
8. Resources	5	0.00E+00
9. Terrestrial Sensitive Environments	***	0.00E+00
10. Targets (lines 5+6c+7+8+9)	**	1.00E+01
11. RESIDENT POPULATION THREAT SCORE	**	9.90E+04

* Maximum value applies to waste characteristics category.
** Maximum value not applicable.
*** No specific maximum value applies, see HRS for details.

SOIL EXPOSURE PATHWAY SCORESHEET

US Army Pine Bluff Arsenal - 10/18/93

SOIL EXPOSURE PATHWAY Factor Categories & Factors NEARBY POPULATION THREAT	Maximum Value	Value Assigned
Likelihood of Exposure		
12. Attractiveness/Accessibility	100	1.00E+01
13. Area of Contamination	100	4.00E+01
14. Likelihood of Exposure	500	5.00E+00
Waste Characteristics		
15. Toxicity	*	1.00E+04
16. Hazardous Waste Quantity	*	10
17. Waste Characteristics	100	18
Targets		
18. Nearby Individual	1	0.00E+00
19. Population Within 1 Mile	**	0.00E+00
20. Targets (lines 18+19)	**	0.00E+00
21. NEARBY POPULATION THREAT SCORE	**	0.00E+00
SOIL EXPOSURE PATHWAY SCORE (Ss)	100	1.20

* Maximum value applies to waste characteristics category.
** Maximum value not applicable.

AIR PATHWAY SCORESHEET

US Army Pine Bluff Arsenal - 10/18/93

AIR MIGRATION PATHWAY Factor Categories & Factors	Maximum Value	Value Assigned
Likelihood of Release		
1. Observed Release	550	0
2. Potential to Release		
2a. Gas Potential to Release	500	0
2b. Particulate Potential to Release	500	280
2c. Potential to Release	500	280
3. Likelihood of Release	550	280
Waste Characteristics		
4. Toxicity/Mobility	*	2.00E+00
5. Hazardous Waste Quantity	*	10
6. Waste Characteristics	100	2
Targets		
7. Nearest Individual	50	2.00E+01
8. Population		
8a. Level I Concentrations	**	0.00E+00
8b. Level II Concentrations	**	0.00E+00
8c. Potential Contamination	**	5.20E+01
8d. Population (lines 8a+8b+8c)	**	5.20E+01
9. Resources	5	5.00E+00
10. Sensitive Environments		
10a. Actual Contamination	***	0.00E+00
10b. Potential Contamination	***	2.30E+01
10c. Sens. Environments(lines 10a+10b)	***	2.30E+01
11. Targets (lines 7+8d+9+10c)	**	1.00E+02
AIR MIGRATION PATHWAY SCORE (Sa)	100	6.79E-01

* Maximum value applies to waste characteristics category.
** Maximum value not applicable.
*** No specific maximum value applies, see HRS for details.

1. WASTESTREAM QUANTITY SUMMARY TABLE, SOURCE: Mustard Dump Yard

a. Wastestream ID	
b. Hazardous Constituent Quantity (C) (lbs.)	0.00
c. Data Complete?	NO
d. Hazardous Wastestream Quantity (W) (lbs.)	0.00
e. Data Complete?	NO
f. Wastestream Quantity Value (W/5,000)	0.00E+00

Documentation for Constituents:

There is insufficient information to determine the hazardous waste constituents; therefore, scoring proceeds to Tier B.

Reference: 1, 2

Documentation for Wastestream Quantity:

There is insufficient information to determine the hazardous wastestream quantity; therefore, scoring proceeds to Tiers C or D.

Reference: 1, 2

2. SOURCE HAZARDOUS WASTE QUANTITY FACTOR TABLE

a. Source ID		Mustard Dump Yard	
b. Source Type		Landfill	
c. Secondary Source Type		Burn Pit	
d. Source Vol.(yd3/gal)	Source Area (ft2)	12000.00	1089000.00
e. Source Volume/Area Value		4.80E+00	
f. Source Hazardous Constituent Quantity (HCQ) Value (sum of 1b)		0.00E+00	
g. Data Complete?		NO	
h. Source Hazardous Wastestream Quantity (WSQ) Value (sum of 1f)		0.00E+00	
i. Data Complete?		NO	
k. Source Hazardous Waste Quantity (HWQ) Value (2e, 2f, or 2h)		4.80E+00	

Source Hazardous Substances	Depth (feet)	Liquid	Concent.	Units
Arsenic	< 2	NO	4.0E+01	ppm
Barium	< 2	NO	1.0E+04	ppm
Chromium	< 2	NO	2.8E+02	ppm
Lead	< 2	NO	1.1E+03	ppm

Documentation for Source Type:

The Old Mustard Dump Yard was used primarily as a burn and disposal area for mustard munitions. The source encompassed approximately 25 acres. There are mounds and trenches scattered across the site as a result of disposal operations (Ref. 5, p. 34). Four parallel trenches on the southern end of the site contained rusted munitions, residue from burning operations and 55-gallon drums. A larger munition pile was west of the 4 trenches. Pits on the northern end of the site contained the remains of tubes which held igniter mix for the munitions. A burn area in the center of the site covers approximately 60,000 square feet. A smaller burn area in the northern portion of the site covers about 10,000 square feet (Ref.

5, pp. 34-35).

Reference: 5

Documentation for Secondary Source Type:

Documentation has indicated that this source had two burn areas (Ref. 5, p. 34).

Reference: 5

Documentation for Source Hazardous Substances:

Contaminants detected at the Mustard Dump source include arsenic at 40 ppm, barium at 10,000 ppm, chromium at 280 ppm, lead at 1100 ppm, and mustard byproducts (Ref. 5, p. 35). Although this reference does not indicate at what depth these contaminants were found, it will be assumed that they were are at depths less than 2 feet.

Reference: 5

Documentation for Source Volume:

It has been estimated that 12,000 cubic yards of contaminated materials exist at this source (Ref. 5, p. 35). Contaminated materials include burn material about 1 foot thick, black mustard residue from 5 to 8 feet, approximately 2 feet of soil beneath the burn areas, and the discarded munition piles (Ref. 5, p. 35).

Reference: 5

Documentation for Source Area:

The site covers approximately 25 acres (Ref. 5, p. 34).

25 acres x 43,560 sq ft/acre = 1,089,000 sq. ft.

Reference: 5, 13

3. SITE HAZARDOUS WASTE QUANTITY SUMMARY

No.	Source ID	Migration Pathways	Vol. or Area Value (2e)	Constituent or Wastestream Value (2f,2h)	Hazardous Waste Qty. Value (2k)
1	Mustard Dump Yard	GW-SW-SE-A	4.80E+00	0.00E+00	4.80E+00

4. PATHWAY HAZARDOUS WASTE QUANTITY AND WASTE CHARACTERISTICS SUMMARY TABLE

Migration Pathway	Contaminant Values		HWQVs*	WCVs**
Ground Water	Toxicity/Mobility	1.00E+02	10	6
SW: Overland Flow, DW	Tox./Persistence	1.00E+04	10	18
SW: Overland Flow, HFC	Tox./Persis./Bioacc.	5.00E+05	10	32
SW: Overland Flow, Env	Etox./Persis./Bioacc.	5.00E+06	10	56
SW: GW to SW, DW	Tox./Persistence	1.00E+02	10	6
SW: GW to SW, HFC	Tox./Persis./Bioacc.	5.00E+04	10	18
SW: GW to SW, Env	Etox./Persis./Bioacc.	5.00E+02	10	6
Soil Exposure:Resident	Toxicity	1.00E+04	10	18
Soil Exposure: Nearby	Toxicity	1.00E+04	10	18
Air	Toxicity/Mobility	2.00E+00	10	2

* Hazardous Waste Quantity Factor Values
** Waste Characteristics Factor Category Values

Note: SW = Surface Water
GW = Ground Water
DW = Drinking Water Threat
HFC = Human Food Chain Threat
Env = Environmental Threat

No.	Aquifer ID	Type	Overlaying No.	Inter-Connected with	Likelihood of Release	Targets
1	Quaternary Alluvium	Non K	0	0	160	5.00E+00
2	Sparta Sand	Non K	1	0	120	3.10E+01

Containment

No.	Source ID	HWQ Value	Containment Value
1	Mustard Dump Yard	4.80E+00	10
	Containment Factor		10

Documentation for Ground Water Containment, Source Mustard Dump Yard:

There is no evidence to indicate that this source was lined. A source that is unlined receives a containment factor value of 10 (Ref. 1, Table 3-2).

Reference: 1

Net Precipitation

Net Precipitation (inches) 23.3

Documentation for Net Precipitation:

The annual net precipitation for Pine Bluff, Arkansas is 23.36 inches (Ref. 8).

Reference: 8

Aquifer: Quaternary Alluvium

Type of Aquifer: Non Karst

Overlaying Aquifer: 0

Interconnected with: 0

Documentation for Quaternary Alluvium Aquifer:

Pine Bluff Arsenal is underlain by two aquifers, the Quaternary sands and gravels of the alluvium and the deeper Tertiary Sparta Sand (Ref. 7, pp. 16-18). The Quaternary alluvium is usually less than 50 feet deep and is used in the surrounding areas for individual residence consumption, farm irrigation, and fish farming. Recharge is primarily by infiltration but along some reaches of the Arkansas River, the river is effluent to the aquifer (Ref. 7, p. 18) and is hydraulically connected with the river (Ref. 4, p. I-13). Direction of ground water flow is generally east towards the Arkansas River (Ref. 4, p. I-13).

Reference: 4, 7

OBSERVED RELEASE

No.	Well ID	Well Type	Distance (miles)	Level of Contamination
- N/A and/or data not specified				

==

Observed Release Factor 0

Documentation for Well MW-166, 167, 168:

In 1982, one upgradient (MW-165) and 3 downgradient monitoring wells (MW-166, MW-167, and MW-168) were installed at the Mustard Burn Pits (Ref.16, p. 12-1). Inorganic contaminants were detected in the wells, however, concentrations in the downgradient wells did not

meet observed release criteria (concentration were not detected at least 3 times the upgradient or backgound well) (Ref. 16, pp. 12-11 - 12-17).

Reference: 1, 16

POTENTIAL TO RELEASE

Containment

Containment Factor 10

Net Precipitation

Net Precipitation Factor 6

Depth to Aquifer

A. Depth of Hazardous Substances 8.00 feet

Documentation for Depth of Hazardous Substances:

Black mustard residue was documented from 5 to 8 feet in one of the boreholes drilled at the source (Ref. 5, p. 35).

Reference: 5

B. Depth to Aquifer from Surface 21.50 feet

Documentation for Depth to Aquifer from Surface :

According to a driller's log of a hole drilled in September 1983 at the waste landfill area, which is located less than a mile from the Mustard Burn Pits, the sand was saturated at 21.5 feet below ground surface (Ref. 9, p. 1).

Reference: 9

C. Depth to Aquifer (B - A) 13.50 feet

Depth to Aquifer Factor	5

Travel Time

Are All Layers Karst?	NO

Documentation for Karst Layers:

There is no documentation to suggest the presence of karst layers.

Reference: 1, 7

Thickness of Layer(s) with Lowest Conductivity	3.00	feet

Documentation for Thickness of Layers with Lowest Conductivity:

According to the driller's log for hole no. 188, there were 3 feet of clay encountered (Ref. 9, p. 1).

Reference: 9

Hydraulic Conductivity (cm/sec)	1.0E-08

Documentation for Hydraulic Conductivity:

Clay has an hydraulic conductivity of 1.E-08 cm/sec (Ref. 1, Table 3-6).

Reference: 1,2

Travel Time Factor 5

==

Potential to Release Factor 160

Aquifer: Sparta Sand

Type of Aquifer: Non Karst

Overlaying Aquifer: 1

Interconnected with: 0

Documentation for Sparta Sand Aquifer:

The Sparta Sand is a confined aquifer and is not believed to be in hydraulic connection with the surface water or the alluvium (Ref. 4, p. I-13). The Sparta Sand supplies water to the arsenal and the City of Pine Bluff. The arsenal wells are 800 to 1,000 feet deep and ranges in thickness between 450 to 800 feet. Recharge is by infiltration in the outcrop area west of Jefferson County and by infiltration from the overlying Quaternary deposits north and southeast of Jefferson County (Ref. 7, p. 18).

Reference: 4, 7

OBSERVED RELEASE

No.	Well ID	Well Type	Distance (miles)	Level of Contamination
- N/A and/or data not specified				

Observed Release Factor 0

POTENTIAL TO RELEASE

Containment

Containment Factor	10	

Net Precipitation

Net Precipitation Factor	6	

Depth to Aquifer

A. Depth of Hazardous Substances	8.00	feet

Documentation for Depth of Hazardous Substances:

Black mustard residue was found from 5 to 8 feet in a borehole drilled at this source (Ref. 5, p. 35).

Reference: 5

B. Depth to Aquifer from Surface	613.00	feet

Documentation for Depth to Aquifer from Surface :

According to a well log for PBA Well No. 14, a medium coarse sand was encountered from 613 to 712 feet below ground surface (Ref. 4, Appendix d, p. D-13).

Reference: 4

C. Depth to Aquifer (B - A)	605.00	feet

Depth to Aquifer Factor 1

Travel Time

Are All Layers Karst? NO

Documentation for Karst Layers:

There is no evidence of karst layers in this area.

Reference: 7

Thickness of Layer(s) with Lowest Conductivity 70.00 feet

Documentation for Thickness of Layers with Lowest Conductivity:

According to PBA Well Log No. 14, there were 70 feet of shale in this well (Ref. 4, Appendix D, p. D-13).

Reference: 4

Hydraulic Conductivity (cm/sec) 1.0E-08

Documentation for Hydraulic Conductivity:

Shale receives an hydraulic conductivity of 1.E-08 cm/sec (Ref. 1, Table 3-6).

Reference: 1

Travel Time Factor 5

Potential to Release Factor 120

Source: 1 Mustard Dump Yard

Source Hazardous Waste Quantity Value: 4.80

Hazardous Substance	Toxicity Value	Mobility Value	Toxicity/ Mobility Value
Arsenic	10000	1.00E-02	1.00E+02
Barium	10	1.00E-02	1.00E-01
Chromium	10000	1.00E-02	1.00E+02
Lead	10000	2.00E-05	2.00E-01

GROUND WATER PATHWAY WASTE CHARACTERISTICS

US Army Pine Bluff Arsenal - 10/18/93

Hazardous Substances Found in an Observed Release

Well No.	Observed Release Hazardous Substance	Toxicity Value	Mobility Value	Toxicity/ Mobility Value

- N/A and/or data not specified

Toxicity/Mobility Value from Source Hazardous Substances:	1.00E+02
Toxicity/Mobility Value from Observed Release Hazardous Substances:	0.00E+00
Toxicity/Mobility Factor:	1.00E+02
Sum of Source Hazardous Waste Quantity Values:	4.80E+00
Hazardous Waste Quantity Factor:	10
Waste Characteristics Factor Category:	6

Population by Well

No.	Well ID	Sample Type	Distance (miles)	Level of Contamination	Population

- N/A and/or data not specified

Level I Population Factor: 0.00

Level II Population Factor: 0.00

Potential Contamination by Distance Category

Distance Category (miles)	Population	Value
> 0 to 1/4	0.0	0.00E+00
> 1/4 to 1/2	0.0	0.00E+00
> 1/2 to 1	0.0	0.00E+00
> 1 to 2	0.0	0.00E+00
> 2 to 3	0.0	0.00E+00
> 3 to 4	0.0	0.00E+00

Potential Contamination Factor: 0.000

Documentation for Target Population > 0 to 1/4 mile Distance Category:

There are no documented alluvial wells within the 0 to 1/4 mile radius.

Reference: 1, 11

Documentation for Target Population > 1/4 to 1/2 mile Distance Category:

There are no documented alluvial wells within the 1/4 to 1/2 mile radius.

Reference: 1, 11

Documentation for Target Population > 1/2 to 1 mile Distance Category:

There are no documented alluvial wells within the 1/2 to 1 mile radius.

Reference: 1, 11

Documentation for Target Population > 1 to 2 miles Distance Category:

There are no documented alluvial wells within the 1 to 2 mile radius.

Reference: 1, 11

Documentation for Target Population > 2 to 3 miles Distance Category:

There are no documented alluvial wells within the 2 to 3 mile radius.

Reference: 1, 11

Documentation for Target Population > 3 to 4 miles Distance Category:

There are no documented alluvial wells within the 3 to 4 mile radius.

Reference: 1, 11

Nearest Well

Level of Contamination: N.A.

Nearest Well Factor: 0.00E+00

Documentation for Nearest Well:

There are no documented drinking water wells within a 4 mile radius in the alluvial aquifer.

Reference: 4

Resources

Resource Use: YES

Resource Factor: 5.00E+00

Documentation for Resources:

Wells in the alluvial aquifer are used for irrigation and fish farming (Ref. 7, p. 18).

Reference: 7

Wellhead Protection Area

No wellhead protection area

Wellhead Protection Area Factor: 0.00E+00

Documentation for Wellhead Protection Area:

There are no public supply wells in the alluvial aquifer.

Reference: 7, pp 17-18

Population by Well

No.	Well ID	Sample Type	Distance (miles)	Level of Contamination	Population

- N/A and/or data not specified

Level I Population Factor: 0.00

Level II Population Factor: 0.00

Potential Contamination by Distance Category

Distance Category (miles)	Population	Value
> 0 to 1/4	0.0	0.00E+00
> 1/4 to 1/2	0.0	0.00E+00
> 1/2 to 1	0.0	0.00E+00
> 1 to 2	607.5	9.40E+00
> 2 to 3	364.5	6.80E+00
> 3 to 4	0.0	0.00E+00

Potential Contamination Factor: 16.000

Documentation for Target Population > 0 to 1/4 mile Distance Category:

There are no documented drinking water wells within the 0 to 1/4 mile radius.

Reference: 1, 4

Documentation for Target Population > 1/4 to 1/2 mile Distance Category:

There are no documented drinking water wells within the 1/4 to 1/2 mile radius.

Reference: 1, 4

Documentation for Target Population > 1/2 to 1 mile Distance Category:

There are no documented drinking water wells within the 1/2 to 1 mile radius.

Reference: 1, 4

Documentation for Target Population > 1 to 2 miles Distance Category:

PBA uses 8 wells for their drinking water source. These wells are all in the Sparta Sand (Ref. 4, pp. I-11 - I-13). There are approximately 972 workers at PBA, therefore each well serves approximately 121.5 persons (Ref. 4, p. I-5). Five of these wells are located within the 1 to 2 mile radius. The total population served by these wells is 607.5.

972 persons/8 wells = 121.5 persons

121.5 x 5 wells = 607.5

Reference: 1, 4

Documentation for Target Population > 2 to 3 miles Distance Category:

The remaining drinking water wells are located within the 2 to 3 mile radius. The total population served by these 3 wells is 364.5 (Ref. 4, p. I-5).

3 x 121.5 = 364.5

Reference: 4

Documentation for Target Population > 3 to 4 miles Distance Category:

There are no documented drinking water wells within the 3 to 4 mile radius.

Reference: 4

<u>Nearest Well</u>

Level of Contamination: Potential
Distance in miles: 1.50

Nearest Well Factor: 5.00E+00

Documentation for Nearest Well:

The nearest well supplying drinking water is PBA Well No. 16, which is located approximately 1.2 miles northest of the Mustard Burn Pits (Ref. 4, pp. I-11 - I-13). This well is in the Sparta Sand and is between 800 to 1,000 feet deep (Ref. 4, p. I-13).

Reference: 4, 11

Resources

Resource Use: YES

Resource Factor: 5.00E+00

Documentation for Resources:

It will be assumed that wells in the Sparta Sand are used for irrigation and aquaculture.

Reference: 1

Wellhead Protection Area

There is a designated wellhead protection area

Wellhead Protection Area Factor: 5.00E+00

Documentation for Wellhead Protection Area:

The exact status of the Wellhead Protection Program in the Pine Bluff area is not known. It will be assumed that a Wellhead Protection Area exists for the Pine Bluff area.

Reference: 1

No.	Segment ID	Segment Type	Water Type	Start Point (mi)	End Point (mi)	Average Flow (cfs)
1	Arkansas River	River	Fresh	0.00	15.00	52324

Documentation for segment: Arkansas River:

The Mustard Burning Yard is adjacent to the Arkansas River. It will be assumed that there is an overland migration path of at least 100 feet before drainage enters the Arkansas. The Arkansas River had an average flow rate of 52,324 cubic feet per second at a gaging station located near Pine Bluff (Ref. 12).

Reference: 11, 12

OBSERVED RELEASE

No.	Sample ID	Sample Type	Distance (miles)	Level of Contamination DW	HFC	Env

- N/A and/or data not specified

Observed Release Factor 0

Documentation for Observed Release, Sample :

There is no sampling data from the Arkansas River; therefore, an observed release to the river cannot be documented.

Reference:

POTENTIAL TO RELEASE

Potential to Release by Overland Flow

Containment

No.	Source ID	HWQ Value	Containment Value
1	Mustard Dump Yard	4.80E+00	10

===

Containment Factor: 10

Documentation for Overland Flow Containment, Source Mustard Dump Yard:

There is no evidence of a maintained engineered cover or functioning and maintained run-on control system and runoff management system. This source receives a surface water containment factor value of 10 (Ref. 1, Table 4-2).

Reference: 1

Distance to Surface Water

Distance to Surface Water:	100.0 feet
Distance to Surface Water Factor:	20

Documentation for Distance to Surface Water:

The distance to the Arkansas River is approximately 100 feet.

Reference: 11

Runoff

A. Drainage Area: 25.0 acres

Documentation for Drainage Area:

The drainage area for the site is 25 acres.

Reference: 11

B. 2-year, 24-hour Rainfall: 4.0 inches

Documentation for Rainfall:

The 2-year, 24-hour rainfall for the area is 4.0 inches.

Reference: 10

C. Soil Group: C
Moderately-fine textured soils with low infiltration rates

Documentation for Soil Group:

The soils around the Mustard Yard Dump are from the Crevasse-Portland association. These soils are deep, somewhat poorly drained and rapidly to very slowly permeable. The sandy and clayey bottom land soils are subject to frequent flooding (Ref. 4, p. I-21).

Reference: 4

Runoff Factor: 1

==

Potential to Release by Overland Flow Factor: 210

Potential to Release by Flood

No.	Source ID	HWQ Value	Flood Containment Value	Flood Frequency Value	Potential to Release by Flood
1	Mustard Dump Yard	4.80E+00	10	25	250

Potential to Release by Flood Factor: 250

Documentation for Flood Containment, Source Mustard Dump Yard:

There is no evidence that this source was contained against flooding. This source receives a flood containment factor value of 10 (Ref. 1, Table 4-8).

Reference: 1

Documentation for Flood Frequency, Source Mustard Dump Yard:

The Mustard Burn Pits are located in the 100-year floodplain of the Arkansas River (Ref. 13, p. 2-1).

Reference: 13

SW PATHWAY: OVERLAND/FLOOD DRINKING WATER THREAT WASTE CHARACTERISTICS

US Army Pine Bluff Arsenal - 10/18/93

Source: 1 Mustard Dump Yard

Source Hazardous Waste Quantity Value: 4.80

Hazardous Substance	Toxicity Value	Persistence Value	Toxicity/ Persistence Value
Arsenic	10000	1.00E+00	1.00E+04
Barium	10	1.00E+00	1.00E+01
Chromium	10000	1.00E+00	1.00E+04
Lead	10000	1.00E+00	1.00E+04

Hazardous Substances Found in an Observed Release

Sample No.	Observed Release Hazardous Substance	Toxicity Value	Persistence Value	Toxicity/ Persistence Value

- N/A and/or data not specified

Toxicity/Persistence Value from Source Hazardous Substances:	1.00E+04
Toxicity/Persistence Value from Observed Release Hazardous Substances:	0.00E+00
Toxicity/Persistence Factor:	1.00E+04
Sum of Source Hazardous Waste Quantity Values:	4.80E+00
Hazardous Waste Quantity Factor:	10
Waste Characteristics Factor Category:	18

Level I Concentrations

- N/A and/or data not specified

Level II Concentrations

- N/A and/or data not specified

Most Distant Level I Sample

- N/A and/or data not specified

Most Distant Level II Sample

- N/A and/or data not specified

Level I Concentrations

Intake	Distance Along the In-water Segment from the Probable Point of Entry (miles)	Population
- N/A and/or data not specified		

Population Served by Level I Intakes: 0.0

Level I Population Factor: 0.00E+00

Level II Concentrations

Intake	Distance Along the In-water Segment from the Probable Point of Entry (miles)	Population
- N/A and/or data not specified		

==

Population Served by Level II Intakes: 0.0

Level II Population Factor: 0.00E+00

Potential Contamination

Intake ID	Average Annual Flow (cfs)	Population Served
- N/A and/or data not specified		

Documentation for Intake :

There are no documented drinking water intakes within the target distance limit in the Arkansas River.

Reference: 13

Type of Surface Water Body	Total Population	Dilution-Weighted Population
- N/A and/or data not specified		

Dilution-Weighted Population Served
by Potentially Contaminated Intakes: 0.0

Potential Contamination Factor: 0.0

Nearest Intake

Location of Nearest Drinking Water Intake: N.A.

Nearest Intake Factor: 0.00

Resources

Resource Use: YES

Resource Value: 5.00E+00

Documentation for Resources:

The Arkansas River is used for contact recreation such as fishing, boating and swimming.

Reference: 14

SW PATHWAY: OVERLAND/FLOOD HUMAN FOOD CHAIN THREAT WASTE CHARACTERISTICS
US Army Pine Bluff Arsenal - 10/18/93

Source: 1 Mustard Dump Yard

Source Hazardous Waste Quantity Value: 4.80

Hazardous Substance	Toxicity Value	Persistence Value	Bio-accum. Value	Toxicity/ Persistence/ Bioaccum. Value
Arsenic	10000	1.00E+00	5.00E+00	5.00E+04
Barium	10	1.00E+00	5.00E-01	5.00E+00
Chromium	10000	1.00E+00	5.00E+00	5.00E+04
Lead	10000	1.00E+00	5.00E+01	5.00E+05

Hazardous Substances Found in an Observed Release

Sample No.	Observed Release Hazardous Substance	Toxicity Value	Persistence Value	Bio-accum. Value	Toxicity/ Persistence/ Bioaccum. Value

- N/A and/or data not specified

Toxicity/Persistence/Bioaccumulation Value from Source Hazardous Substances:	5.00E+05
Toxicity/Persistence/Bioaccumulation Value from Observed Release Hazardous Substances:	0.00E+00
Toxicity/Persistence/Bioaccumulation Factor:	5.00E+05
Sum of Source Hazardous Waste Quantity Values:	4.80E+00
Hazardous Waste Quantity Factor:	10
Waste Characteristics Factor Category:	32

Level I Concentrations

- N/A and/or data not specified

Level II Concentrations

- N/A and/or data not specified

Most Distant Level I Sample

- N/A and/or data not specified

Most Distant Level II Sample

- N/A and/or data not specified

Level I Concentrations

Fishery	Annual Production (pounds)	Human Food Chain Population Value
- N/A and/or data not specified		

Sum of Human Food Chain Population Values: 0.00E+00

Level I Concentrations Factor: 0.00E+00

Level II Concentrations

Fishery	Annual Production (pounds)	Human Food Chain Population Value
- N/A and/or data not specified		

Sum of Human Food Chain Population Values: 0.00E+00

Level II Concentrations Factor: 0.00E+00

Potential Contamination

Fishery	Annnual Production (pounds)	Type of Surface Water Body	Average Annual Flow (cfs)	Pop. Value (Pi)	Dilution Weight (Di)	Pi*Di
1 Arkansas River	100.0	River	52324	0.3	1.00E-04	3.00E-05

Sum of (Pi*Di): 3.00E-05

Potential Human Food Chain Contamination Factor: 3.00E-06

Documentation for Arkansas River Fishery:

There is no documentation of the annual production of human chain organisms consumed from the Arkansas River. It will be assumed that at least 100 pounds are consumed annually.

Reference: 1

Food Chain Individual

Location of Nearest Fishery: Arkansas River
Distance from the Probable Point of Entry: 0.00 miles
Type of Surface Water Body: River
Dilution Weight: 0.0001000
Level of Contamination: Potential

Food Chain Individual Factor: 0.00

Documentation for Arkansas River:

The Mustard Burning Yard is adjacent to the Arkansas River. It will be assumed that there is an overland migration path of at least 100 feet before drainage enters the Arkansas. The Arkansas River had an average flow rate of 52,324 cubic feet per second at a gaging station located near Pine Bluff (Ref. 12).

Reference: 11, 12

Source: 1 Mustard Dump Yard

Source Hazardous Waste Quantity Value: 4.80

Hazardous Substance	Eco-toxicity Value	Persistence Value	Bio-accum. Value	Ecotoxicity/ Persistence/ Bioaccum. Value
Arsenic	10	1.00E+00	5.00E+01	5.00E+02
Barium	1	1.00E+00	5.00E-01	5.00E-01
Chromium	10000	1.00E+00	5.00E+00	5.00E+04
Lead	1000	1.00E+00	5.00E+03	5.00E+06

Hazardous Substances Found in an Observed Release

Sample No.	Observed Release Hazardous Substance	Eco-toxicity Value	Persistence Value	Bio-accum. Value	Ecotoxicity/ Persistence/ Bioaccum. Value

- N/A and/or data not specified

Ecotoxicity/Persistence/Bioaccummulation Value from Source Hazardous Substances:	5.00E+06
Ecotoxicity/Persistence/Bioaccummulation Value from Observed Release Hazardous Substances:	0.00E+00
Ecotoxicity/Persistence/Bioaccummulation Factor:	5.00E+06
Sum of Source Hazardous Waste Quantity Values:	4.80E+00
Hazardous Waste Quantity Factor:	10
Waste Characteristics Factor Category:	56

Level I Concentrations

- N/A and/or data not specified

Level II Concentrations

- N/A and/or data not specified

Most Distant Level I Sample

- N/A and/or data not specified

Most Distant Level II Sample

- N/A and/or data not specified

Level I Concentrations

Sensitive Environment	Distance from Probable Point of Entry to Sensitive Env. (miles)	Sensitive Environment Value
- N/A and/or data not specified		

Sum of Sensitive Environments Values: 0

Wetlands

Wetland	Distance from Probable Point of Entry to Wetland (miles)	Wetlands Frontage (miles)
- N/A and/or data not specified		

Total Wetlands Frontage: 0.00 Miles Total Wetlands Value: 0

Sum of Sensitive Environments Value + Wetlands Value: 0.00E+00

Level I Concentrations Factor: 0.00E+00

Level II Concentrations

Sensitive Environment	Distance from Probable Point of Entry to Sensitive Env. (miles)	Sensitive Environment Value
- N/A and/or data not specified		

Sum of Sensitive Environments Values: 0

Wetlands

Wetland	Distance from Probable Point of Entry to Wetland (miles)	Wetlands Frontage (miles)
- N/A and/or data not specified		

Total Wetlands Frontage: 0.00 Miles Total Wetlands Value: 0

==

Sum of Sensitive Environments Value + Wetlands Value: 0.00E+00

Level II Concentrations Factor: 0.00E+00

Potential Contamination

Sensitive Environments

Type of Surface Water Body	Sensitive Environment	Sensitive Environment Value

Wetlands

Type of Surface Water Body	Sensitive Environment	Wetlands Frontage	Wetlands Value
River	1 Wetlands	4.00	100

Documentation for Sensitive Environment Wetlands:

There are an estimated 4 miles of wetlands frontage along the Arkansas River approximately 2 miles downstream from the PPE.

Reference: 11

SW PATHWAY: OVERLAND FLOW/FLOOD COMPONENT ENVIRONMENTAL THREAT TARGETS

US Army Pine Bluff Arsenal - 10/18/93

Type of Surface Water Body	Sum of Sens. Environment Values(Sj)	Sum of Wetland Frontage Values(Wj)	Dilution Weight (Dj)	Dj(Wj+Sj)
Large River	0	100	1.00E-04	1.00E-02

Sum of Dj(Wj+Sj):	1.00E-02
Sum of Dj(Wj+Sj)/10:	1.00E-03

===

Potential Contamination Sensitive Environment Factor: 1.00E-03

Likelihood of Exposure

No.	Source ID	Level of Contamination
1	Mustard Dump Yard	Level I

Likelihood of Exposure Factor: 550

Documentation for Area of Contamination, Source Mustard Dump Yard:

Approximately four acres of the Mustard Burn Pits are covered with contaminated soil. The majority of the soil is burned residue from various types of disposal operations. Contaminated soil ranged from 0 to 2 feet below the burned fill (Ref. 13, p. 3-6).

4 acres x 43,560 sq. ft./acre = 174,240 sq. ft.

Reference: 13

Source No.	Hazardous Substance	Depth (ft.)	Concent.	Cancer	RFD	Units
1	Arsenic	< 2	4.0E+01	3.3E-01	1.7E+02	ppm
1	Barium	< 2	1.0E+04	0.0E+00	4.1E+04	ppm
1	Chromium	< 2	2.8E+02	0.0E+00	2.9E+03	ppm
1	Lead	< 2	1.1E+03	0.0E+00	0.0E+00	ppm

Documentation for Source Mustard Dump Yard, Contaminants:

Contaminants detected at the Mustard Dump source include arsenic at 40 ppm, barium at 10,000 ppm, chromium at 280 ppm, lead at 1100 ppm, and mustard byproducts (Ref. 5, p. 35). Although this reference does not indicate at what depth these contaminants were found, it will be assumed that they were are at depths less than 2 feet.

Reference: 5

SOIL EXPOSURE PATHWAY RESIDENT POPULATION THREAT WASTE CHARACTERISTICS
US Army Pine Bluff Arsenal - 10/18/93

Source: 1 Mustard Dump Yard

Source Hazardous Waste Quantity Value: 32.03

Hazardous Substance	Toxicity Value
Arsenic	10000
Barium	10
Chromium	10000
Lead	10000

Toxicity Factor:	1.00E+04
Sum of Source Hazardous Waste Quantity Values:	3.20E+01
Hazardous Waste Quantity Factor:	10
Waste Characteristics Factor Category:	18

Targets

Level I Population: 0.0 Value: 0.00

Documentation for Level I Population:

There are no documented Level I concentrations.

Reference: 1

Level II Population: 0.0 Value: 0.00

Documentation for Level II Population:

There are no documented Level II concentrations.

Reference: 1

Workers: 972.0 Value: 10.00

Documentation for Workers:

The current number of employees at the Pine Bluff Arsenal is not known; however at the time of the Installation Assessment of PBA in 1977, PBA employed 972 civilian and military personnel (Ref. 4, p. I-5).

Reference: 1, 4

Resident Individual: Potentia Value: 0.00

Resources: NO Value: 0.00

Documentation for Resources:

There is no evidence that there is commercial agriculture, silviculture, livestock production or grazing at the PBA.

Reference: 1, 4

Terrestial Sensitive Environment	Value
- N/A and/or data not specified	

==

Terrestrial Sensitive Environments Factor: 0.00

Likelihood of Exposure

No.	Source ID	Level of Contamination	Attractiveness/ Accessibility	Area of Contam. (sq. feet)
1	Mustard Dump Yard	Level I	10	174240

Highest Attractiveness/Accessibility Value: 10
Sum of Eligible Areas Of Contamination (sq. feet): 174240
Area of Contamination Value: 40

Likelihood of Exposure Factor Category: 5

Documentation for Attractiveness/Accessibility, Source Mustard Dump Yard:

There is no evidence of public recreation at PBA. The current security conditions and fencing around PBA are not known; it will be assumed that it is physically accessible to the public via the Arkansas River. The Mustard Burn Yard is evaluated as accessible, with no public recreation and receives a value of 10.

Reference: 1, 4

Source No.	Hazardous Substance	Depth (ft.)	Concent.	Cancer	RFD	Units
1	Arsenic	< 2	4.0E+01	3.3E-01	1.7E+02	ppm
1	Barium	< 2	1.0E+04	0.0E+00	4.1E+04	ppm
1	Chromium	< 2	2.8E+02	0.0E+00	2.9E+03	ppm
1	Lead	< 2	1.1E+03	0.0E+00	0.0E+00	ppm

Documentation for Source Mustard Dump Yard, Contaminants:

Contaminants detected at the Mustard Dump source include arsenic at 40 ppm, barium at 10,000 ppm, chromium at 280 ppm, lead at 1100 ppm, and mustard byproducts (Ref. 5, p. 35). Although this reference does not indicate at what depth these contaminants were found, it will be assumed that they were are at depths less than 2 feet.

Reference: 5

SOIL EXPOSURE PATHWAY NEARBY POPULATION THREAT WASTE CHARACTERISTICS

US Army Pine Bluff Arsenal - 10/18/93

Source: 1 Mustard Dump Yard

Source Hazardous Waste Quantity Value: 32.03

Hazardous Substance	Toxicity Value
Arsenic	10000
Barium	10
Chromium	10000
Lead	10000

Toxicity Factor:	1.00E+04
Sum of Source Hazardous Waste Quantity Values:	3.20E+01
Hazardous Waste Quantity Factor:	10
Waste Characteristics Factor Category:	18

Nearby Individual

Population within 1/4 mile: 0.0

Nearby Individual Value: 0.0

Population Within 1 Mile

Travel Distance Category	Number of People	Value
> 0 to 1/4 mile	0.0	0.0
> 1/4 to 1/2 mile	0.0	0.0
> 1/2 to 1 mile	0.0	0.0

Population Within 1 Mile Factor: 0.0

Documentation for Population > 0 to 1/4 mile Distance Category:

There is no documented population within the 0 to 1/4-mile radius of the Mustard Burn Pits.

Reference: 11, 15

Documentation for Population > 1/4 to 1/2 mile Distance Category:

There is no documented population within the 1/4 to 1/2 mile-radius from the Mustard Burn Pits.

Reference: 11, 15

Documentation for Population > 1/2 to 1 mile Distance Category:

There is no documented population within the 1/2 to 1-mile radius from the Mustard Burn Pits.

Reference: 11, 15

OBSERVED RELEASE

No.	Sample ID	Distance (miles)	Level of Contamination
	- N/A and/or data not specified		

Observed Release Factor: 0

Documentation for Sample :

There is no documentation of air samples collected documenting an air release from the Mustard Burn Pits.

Reference: 4, 13

Gas Migration Potential

GAS POTENTIAL TO RELEASE

Source ID	Source Type	Gas Contain. Value (A)	Gas Source Type Value (B)	Gas Migrtn. Potent. Value (C)	Sum (B+C)	Gas Potential to Rel. Value A(B+C)
- N/A and/or data not specified						

Gas Potential to Release Factor: 0

Documentation for Gas Containment, Source Mustard Dump Yard:

This source has a contaminated cover and is not heavily vegetated (Ref. 6, p. 54). A source with an uncontaminated soil cover less than 1 foot and is not heavily vegetated receives a gas containment factor value of 10 (Ref. 1, Table 6-3).

Reference: 1, 6

Documentation for Source Type, Source Mustard Dump Yard:

The Old Mustard Dump Yard was used primarily as a burn and disposal area for mustard munitions. The source encompassed approximately 25 acres. There are mounds and trenches scattered across the site as a result of disposal operations (Ref. 5, p. 34). Four parallel trenches on the southern end of the site contained rusted munitions, residue from burning operations and 55-gallon drums. A larger munition pile was west of the 4 trenches. Pits on the northern end of the site contained the remains of tubes which held igniter mix for the munitions. A burn area in the center of the site covers approximately 60,000 square feet. A smaller burn area in the northern portion of the site covers about 10,000 square feet (Ref. 5, pp. 34-35).

Reference: 5

Documentation for Secondary Source Type, Mustard Dump Yard:

Documentation has indicated that this source had two burn areas (Ref. 5, p. 34).

Reference: 5

Source: Mustard Dump Yard

Gaseous Hazardous Substance	Hazardous Substance Gas Migration Potential Value

Average of Gas Migration Potential Value for 3 Hazardous Substances: 0.000

===

Gas Migration Potential Value From Table 6-7: 0

Particulate Migration Potential

PARTICULATE POTENTIAL TO RELEASE

Source ID	Source Type	Partic. Contain. Value (A)	Partic. Source Type Value (B)	Partic. Migrtn. Potent. Value (C)	Sum (B+C)	Partic. Potential to Rel. Value A(B+C)
Mustard Dump Yard	Landfill	10	22	6	28	280

Particulate Potential to Release Factor: 280

Documentation for Particulate Containment, Source Mustard Dump Yard:

This source has a contaminated soil cover and is not heavily vegetated (Ref. 6, p. 54). A source with an uncontaminated soil cover less than 1 foot and is not heavily vegetated receives a containment factor value of 10 (Ref. 1, Table 6-9).

Reference: 1, 6

Documentation for Source Type, Source Mustard Dump Yard:

The Old Mustard Dump Yard was used primarily as a burn and disposal area for mustard munitions. The source encompassed approximately 25 acres. There are mounds and trenches scattered across the site as a result of disposal operations (Ref. 5, p. 34). Four parallel trenches on the southern end of the site contained rusted munitions, residue from burning operations and 55-gallon drums. A larger munition pile was west of the 4 trenches. Pits on the northern end of the site contained the remains of tubes which held igniter mix for the munitions. A burn area in the center of the site covers approximately 60,000 square feet. A smaller burn area in the northern portion of the site covers about 10,000 square feet (Ref. 5, pp. 34-35).

Reference: 5

Documentation for Secondary Source Type, Mustard Dump Yard:

Documentation has indicated that this source had two burn areas (Ref. 5, p. 34).

Reference: 5

Documentation for Particulate Migration Potential:

According to Figure 6-2 of the HRS Manual, the site receives a particulate migration potential factor value of 6.

Reference: 1

Source: Mustard Dump Yard

Particulate Hazardous Substance
Arsenic
Barium
Chromium
Lead

AIR PATHWAY WASTE CHARACTERISTICS
US Army Pine Bluff Arsenal - 10/18/93

Source: 1 Mustard Dump Yard

Source Hazardous Waste Quantity Value: 4.80

Hazardous Substance	Toxicity Value	Gas Mobility Value	Particulate Mobility Value	Toxicity/ Mobility Value
Arsenic	10000	NA	2.00E-04	2.00E+00
Barium	10	NA	2.00E-04	2.00E-03
Chromium	10000	NA	2.00E-04	2.00E+00
Lead	10000	NA	2.00E-04	2.00E+00

Hazardous Substances Found in an Observed Release

Sample ID	Observed Release Hazardous Substance	Particulate Toxicity/ Mobility Value	Gas Toxicity/ Mobility Value

- N/A and/or data not specified

Documentation for Particulate Mobility:

According to Figure 6-3 in the HRS Manual, the site receives a particulate mobility factor value of .0002.

Reference: 1

AIR PATHWAY WASTE CHARACTERISTICS
US Army Pine Bluff Arsenal - 10/18/93

Toxicity/Mobility Value from Source Hazardous Substances:	2.00E+00
Toxicity/Mobility Value from Observed Release Hazardous Substances:	0.00E+00
Toxicity/Mobility Factor:	2.00E+00
Sum of Source Hazardous Waste Quantity Values:	4.80E+00
Hazardous Waste Quantity Factor:	10
Waste Characteristics Factor Category:	2

Actual Contamination

No.	Sample ID	Distance (miles)	Level of Contamination

- N/A and/or data not specified

Potential Contamination

Distance Categories Subject to Potential Contamination	Population	Value
Onsite	972.0	52.2000
> 0 to 1/4 mile	0.0	0.0000
> 1/4 to 1/2 mile	0.0	0.0000
> 1/2 to 1 mile	0.0	0.0000
> 1 to 2 miles	0.0	0.0000
> 2 to 3 miles	545.0	0.1000
> 3 to 4 miles	543.0	0.0700

Potential Contaminantion Factor: 52.0000

Documentation for Population Onsite Distance Category:

There were 972 workers at PBA in 1977 (Ref. 4, p. I-5).

Reference: 4

Documentation for Population > 0 to 1/4 mile Distance Category:

There is no documented population within the 0 to 1/4 mile radius.

Reference: 11, 15

Documentation for Population > 1/4 to 1/2 mile Distance Category:

There is no documented population within the 1/4 to 1/2 mile radius.

Reference: 11, 15

Documentation for Population > 1/2 to 1 mile Distance Category:

There is no documented popualation within the 1/2 to 1 mile radius.

Reference: 11, 15

Documentation for Population > 1 to 2 miles Distance Category:

There is no documented population within the 1 to 2 mile radius.

Reference: 11, 15

Documentation for Population > 2 to 3 miles Distance Category:

According to the TGEMS, there are 545 persons within the 2 to 3 mile radius.

Reference: 15

Documentation for Population > 3 to 4 miles Distance Category:

According to TGEMS, there are 543 persons within the 3 to 4 mile radius.

Reference: 15

Nearest Individual Factor

Level of Contamination: Potential
Distance in miles: 0 to 1/8

Nearest Individual Value: 20

Documentation for Nearest Individual:

The nearest regularly occupied building is located approximately 1,200 feet or .23 miles to the northwest of the Mustard Burn Pits.

Reference: 11

Resources

Resource Use: YES

Resource Value: 5

Documentation for Resources:

The Arkansas River, which is a designated recreation area (fishing and boating), is adjacent to the Mustard Burn Pits.

Reference: 11, 14

Actual Contamination, Sensitive Environments

Sensitive Environment	Distance (miles)	Sensitive Environment Value
- N/A and/or data not specified		

Actual Contamination, Wetlands

Distance Category	Wetland Acreage	Wetland Acreage Value
- N/A and/or data not specified		

==

Sensitive Environments Actual Contamination Factor: 0.000
(Sum of Sensitive Environments + Wetlands Values)

Potential Contamination, Sensitive Environments

Sensitive Environment	Distance (miles)	Sensitive Environment Value	Distance Weight	Weighted Value/10
Mississippi Wolf	0.000	75	1.0000	7.500
Peregrine Falcon	0.000	75	1.0000	7.500
Red-cockaded Woodpe	0.000	75	1.0000	7.500

Sum of Sensitive Environments Weighted Values/10: 22.500

Potential Contamination, Wetlands

Distance Category	Wetland Acreage	Wetland Acreage Value	Distance Weight	Weighted Value/10
> 1/4 to 1/2 mile	30.0	25.0	0.0540	0.135

Total Wetland Acreage: 30.0

Sum of Wetland Weighted Acreage Values/10: 0.135

Sensitive Environment Potential Contamination Factor: 23.000

Documentation for Sensitive Environment Mississippi Wolf:

There have been previous reports, but no capture records of the Mississippi Valley Red Wolf (Canis rufus gregori), which is a Federal endangered species (Ref. 4, p. I-17). A terrestrial habitat known to be used by a Federal designated species receives a rating value of 75 (Ref. 1, Table 5-5).

Reference: 1, 4

Documentation for Sensitive Environment Peregrine Falcon:

The Peregrine Falcon (Falco peregrinus) have been reported at PBA. The falcons were located in the wetlands of PBA (Ref. 4, p. I-17).

Reference: 1, 4

Documentation for Sensitive Environment Red-cockaded Woodpe:

The Red-cockaded Woodpecker (Dendrocopus borealis) has been reported at PBA. A ten acre tract of pines was set aside around the nest-site trees (Ref. 4, I-17). The exact location of this tract is not known.

Reference: 1, 4

Documentation for Sensitive Environment Wetlands:

There are an estimated 30 acres of wetlands within 1/4 to 1/2 mile of the Mustard Burn Pits.

Reference: 11

PRE-SCORE

REFERENCE 1

12-14-90
Vol. 55 No. 241

federal register

Friday
December 14, 1990

Book 2

United States
Government
Printing Office
SUPERINTENDENT
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Washington DC 20402

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Postage and Fees Paid
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(ISSN 0097-6326)

PRE-SCORE

REFERENCE 2

Publication 9345.1-04
September 1991

PREscore Software
USERS MANUAL & TUTORIAL
VERSION 1.0

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Office of Solid Waste and Emergency Response
Office of Emergency and Remedial Response
Hazardous Site Evaluation Division
Washington, DC 20460

PRE-SCORE

REFERENCE 3

Handout #8

SUPERFUND CHEMICAL DATA MATRIX

March 1993

PRE-SCORE

REFERENCE 4

INSTALLATION ASSESSMENT

OF

PINE BLUFF ARSENAL

RECORDS EVALUATION REPORT NO. 113

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FOREWORD

This Installation Assessment Report was prepared in August 1977 to document potential and actual contamination problems at Pine Bluff Arsenal so that these problems could be addressed in the Army's Installation Restoration program. A brief discussion of the positive steps which have been implemented to further identify and eliminate problem areas is contained in Appendix U.

EXECUTIVE SUMMARY

I. GENERAL

A. During May 1977, a records search was conducted on Pine Bluff Arsenal (PBA) to confirm previously known areas of contamination and to determine if other undocumented contaminated areas exist.

B. The on-site phase of the search was performed from 23 through 27 May 1977; however, data were collected from other agency sources beginning 18 April through 5 August 1977. In addition to the on-site search, Team members also contacted personnel at Aberdeen Proving Ground who were familiar with past operations at Pine Bluff Arsenal.

C. The procedure followed by the Records Research Team included:

1. Acquiring all pertinent documents on PBA from other government agencies including:

   a. Department of Defense Explosive Safety Board (DDESB).

   b. US Army Environmental Hygiene Agency (AEHA).

   c. US Geological Survey (USGS).

   d. Defense Documentation Center (DDC).

   e. US Army Engineer Waterways Experiment Station (WES).

   f. National Technical Information Service (NTIS).

2. Obtaining copies of all on-site installation regulations, standing operating procedures, and other available documentation.

3. Interrogating former and present key employees.

4. Analysis of above pertinent data.

D. This report reflects the status of Pine Bluff Arsenal as of 5 August 1977.*

*Appendix T contains information received from PBA on 23 December 1977 which up dated the mission, organization chart, and manpower distribution at the Arsenal. It also includes information on installation activities addressing environmental pollution and contamination control.

II. FINDINGS

A. Pine Bluff Arsenal is contaminated with hazardous wastes resulting from various operations conducted at the Arsenal from 1942 to the present both by government agencies and by industrial concerns that leased portions of the facility. Potential contaminants identified from the search of records are DDT, arsenic, white phosphorus, barium, zinc, mustard, BZ, riot control agents, pyrotechnic materials, and industrial wastes with their associated waste products.

B. Sterilized biological waste was disced into the soil in a field on the property deeded to the National Center for Toxicological Research (NCTR). The buildings presently used by NCTR were formerly the facilities of the Directorate of Biological Operations (DBO) at PBA.

C. Many test areas at PBA may contain unexploded ordnance (UXO). The UXO potentially consists of high explosive rounds, mustard rounds, pyrotechnic munitions (WP, HC, smoke, colored signals), and riot control devices (CS and CN).

D. Radiological materials were not developed, manufactured, stored, tested, or disposed of at the installation.

E. Lethal chemical agents (mustard and lewisite) were manufactured at PBA and mustard agent is presently stored at the Toxic Storage Yard (TSY). Other items in storage at the TSY include War Gas Identification Sets, riot control agents, decontaminants and FS. GB and VX are stored in igloos in the ammunition storage area. BZ is stored in three igloos in the ammunition storage area.

F. Groundwater and the subsurface soil is contaminated in many areas of the installation. Thirty-two sites within the boundary were evaluated by sampling and analyzing for DDT, sodium, barium, arsenic, mercury, lead, zinc, mustard, lewisite, CS, CN, DM, dyes, hexachloroethane, and white phosphorus. Twenty-nine of the sites had at least two or more contaminants at concentrations in excess of critical threshold values established by a team of scientists at the Chemical Systems Laboratory.

III. CONCLUSION

Current known areas of contamination were substantiated and additional suspected areas were located and documented.

IV. RECOMMENDATION

The preliminary surveys presently being conducted at PBA should continue because there is a strong potential for contaminant migration.

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Q	AEHA Water Quality Geohydrologic Consultation No. 24-004-74, dated 16 - 20 July 1973
R	Edgewood Arsenal Technical Report No. EO-TR-76077, Effects of Elemental Phosphorus on the Biota of Yellow Lake, PBA, dated December 1976
S	Edgewood Arsenal Technical Report No. EB-TR-76038, Results of Aquatic Surveys at PBA, dated April 1976
T	Pine Bluff Arsenal Input, 23 December 1977
U	Installation Restoration Accomplishments As Of Oct 79

I. GENERAL

A. Purpose of the Assessment

1. To confirm previously known areas of contamination and to determine from a search of available records if other undocumented contaminated areas exist at Pine Bluff Arsenal (PBA). This information, as applicable, will be incorporated into the ongoing PBA survey.

2. To identify any immediate on-post safety problems.

B. Authority

Department of the Army (DA) Charter for the Project Manager for Chemical Demilitarization and Installation Restoration (PM CDIR) dated 29 April 1977.

C. Introduction

1. In response to a request from the Office of the Project Manager for Chemical Demilitarization and Installation Restoration, the Records Research Team initiated a search of PBA records.

2. Personnel from PBA were briefed on the program prior to the start of the on-site records search. This briefing outlined the scope of the assessment and provided guidelines to installation personnel. Mr. Glen Murtha was designated the point of contact for the Team.

3. Prior to the review of on-site records, various Government agencies were contacted during the period of 18 April through 20 May 1977 for documents pertinent to the records research effort. These agencies were:

a. Department of Defense Explosive Safety Board (DDESB).

b. US Army Environmental Hygiene Agency (AEHA).

c. US Geological Survey (USGS).

d. Defense Documentation Center (DDC).

e. US Army Engineer Waterways Experiment Station (WES).

f. National Technical Information Service (NTIS).

4. The following personnel were assigned to the Team and provided input to this report:

a. Mr. William Collins (Team Leader/Chemical Engineer).

b. Mr. Norman Leibel (Ordnance Specialist).

c. Mr. Harry Woods (Hydrogeologist).

d. Mr. John Bane (Chemist).

e. Mr. Reed Magness (Chemist).

f. LT Charles Brenner (Chemical Engineer).

g. Mr. James Scott (PM CDIR Representative/Chemist).

5. In addition to the review of records, interviews were conducted with more than 25 persons, including present and former employees (see Appendix A). A ground tour of the installation was also made. Photographs taken during the tour are included in Appendix B. Team members also contacted and interviewed personnel at Aberdeen Proving Ground who either were former employees at PBA or were knowledgeable of certain operations conducted there.

6. The findings, conclusion, and recommendations are based on the records made available to the Team at the time of the search, and the Team cannot vouch for the accuracy of the records. Where conspicuous discrepancies existed within the data, attempts were made to determine the correct information by interviewing the personnel (if available) involved in preparing the original data.

D. Summary Description of Installation

1. Location and Size

PBA is located in the central portion of Jefferson County, Arkansas. It lies approximately eight miles northeast of Pine Bluff and 30 miles southeast of Little Rock. PBA lies on the west side of the Arkansas River and is 120 miles upstream from its junction with the Mississippi River. The Arsenal is approximately 400 miles from the Gulf of Mexico and over 800 miles from the Atlantic Ocean.

PBA presently contains 14,454 acres of land including 67 acres of perpetual easements acquired for railroad and natural gas distribution line right of ways between the Arsenal and the city of Pine Bluff, and 100 acres leased to the city of Pine Bluff for construction of a secondary sewage treatment facility (oxidation pond) for domestic sewage. In addition, this review includes approximately 500 acres known as the old Biological Plant now deeded to and under the control of the Food and Drug Administration and operated as the National Center for Toxicological Research (NCTR) (see Figure I-1).

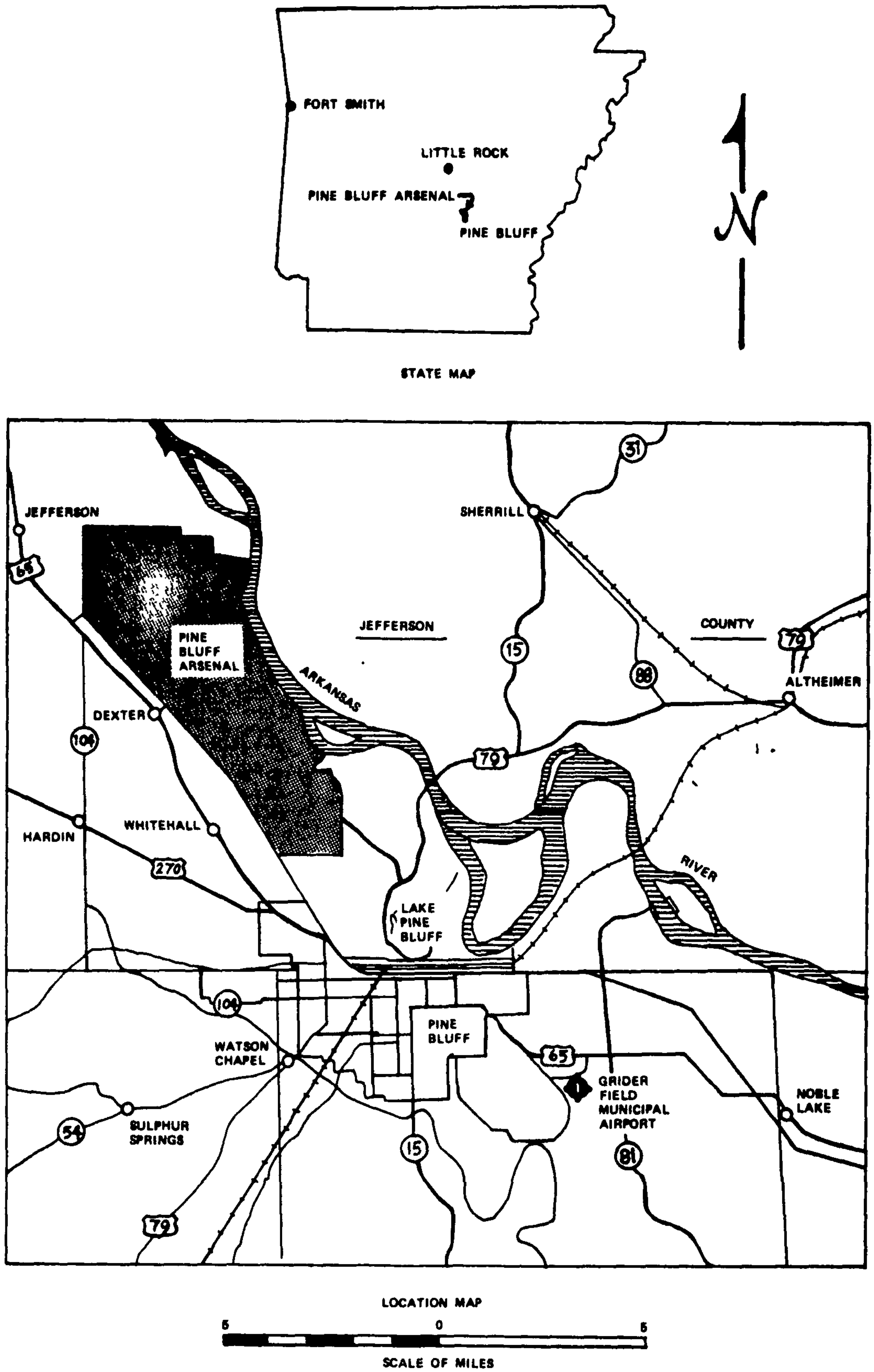


FIGURE I-1. SITE MAP FOR PINE BLUFF ARSENAL, PINE BLUFF, ARKANSAS

2. Area Description

Jefferson County was founded in 1829 and is located in the central portion of the state. It is the second most populated county in the state with a population of approximately 90,000. The Arkansas River flows diagonally through the county in a southeasterly manner and borders both Pine Bluff and PBA. Pine Bluff is the county seat of Jefferson County, with a population of over 58,000 residents. Little Rock, the capital of Arkansas, is located 30 miles northwest of the Arsenal and has a population of over 135,000. Approximately 3,000 residents live within a one mile radius of the installation. This figure includes over 1,900 residents in the town of Whitehall adjoining the south-eastern boundary of the Arsenal.

The nearest counties are: Pulaski to the north with a population of over 287,000; Grant to the west with a population of over 9,700; Arkansas to the east with a population of over 23,300; and Cleveland and Lincoln to the south with populations of over 6,600 and 12,900 respectively.

PBA is bordered on the north by privately owned timber and farmland while the southern boundary is adjacent to industrial properties of which the Weyerhauser Company is the largest owner. The western boundary is adjacent to the Missouri Pacific Railway and the eastern boundary is contiguous to the Arkansas River. The land on the southern half of the Arsenal is flat while the northern half is slightly rolling. PBA is served by US Highway 65 on the west which connects Pine Bluff with Little Rock, and State Highway 79 which serves the Arsenal from the southeast by means of a two mile county road. Several major airlines serve the general area from Adams Field in Little Rock.

The land on the eastern side of the Arkansas River is relatively flat, well adapted to farming and growing hardwood timber. Numerous drainage canals and reservoirs have been built to provide water for irrigation, recreation, and fish farming. The terrain to the west of the river is flat to rolling and is predominately adapted to growing timber. There are numerous industrial plants in the area, all of which are on the west side of the Arkansas River. Industry is expected to increase in the area since the Arkansas River is now navigable from Tulsa, Oklahoma, to the Mississippi River, due to the recently completed Arkansas River Development Program.

The climate in the PBA area is considered to be mild with a mean annual temperature of 62.2°F. The average growing season is 244 days with the last killing frost expected on or about 25 March and the first killing frost expected on or about 14 November. The average rainfall for the Arsenal area is about 50 inches per year.

3. Organization and Mission

a. The mission of PBA is:

(1) The production, manufacture, receipt, storage, shipment, surveillance, testing, maintenance, and demilitarization of chemical munitions to include chemicals, smokes, riot control, incapacitating, incendiary, and pyrotechnic mixes, for military application and to supplement commercial industrial capacity.

(2) The support of research, development, and engineering requirements of other US Army Materiel Development and Readiness Command (DARCOM) programs.

(3) The development of plans for supporting mobilization requirements and schedules prepared by DARCOM relevant to the Industrial Readiness Assurance Program for US Army Armament Materiel Readiness Command (ARRCOM) items.

(4) The procurement of raw materials for accomplishment of mission responsibilities.

(5) The administrative and logistical support for attached and/or tenant activities.

(6) The maintenance of facilities and equipment in a readiness condition.

b. PBA is a Class II DARCOM installation assigned to the command jurisdiction of the commander, ARRCOM. The Arsenal's personnel strength is currently 972 employees (13 officers, 47 enlisted men, and 912 civilians). See Organization Chart, Figure I-2, and Manpower Distribution Chart, Figure I-3, for details.

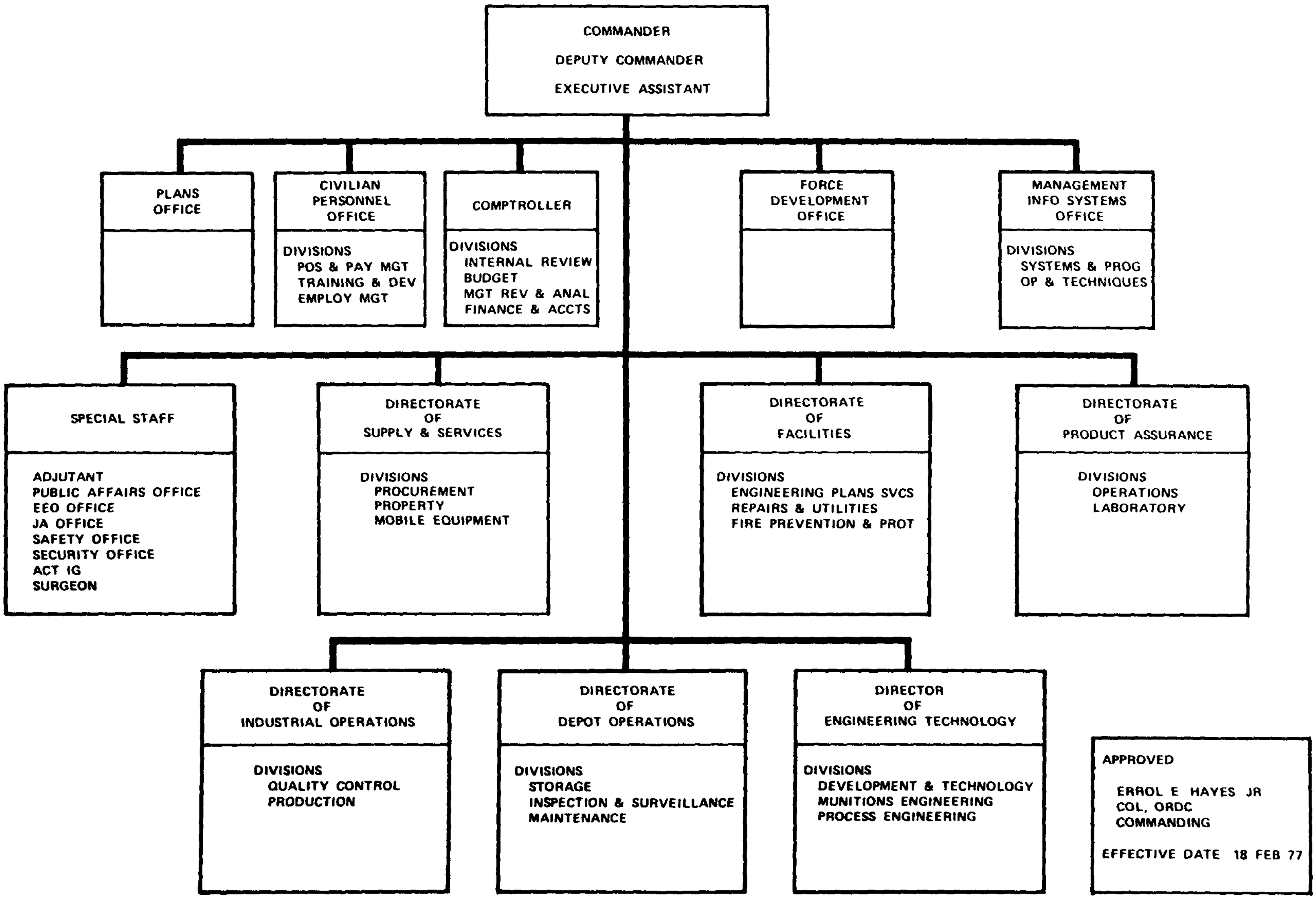
The number of personnel at PBA has fluctuated over the years, from a high of over 9,000 civilian and 450 military to a low of 700 civilians and 125 military during the period between World War II and the Korean Conflict. The Vietnam Conflict increased personnel strength to a high of 140 military and 1,850 civilians in June 1968. Strength has gradually decreased from that date to the present strength of 972 total (60 military and 912 civilians, See Appendix T).

4. History

The Arsenal was established by the War Department on 10 November 1941 and originally designated the Chemical Warfare Arsenal, Pine Bluff, Arkansas. Headquarters was established in the National Building in Pine Bluff, Arkansas. Construction of the Arsenal began on 2 December 1941. Construction included facilities for manufacture, loading, and assembly of incendiary and chemical munitions, storage magazines, laboratories, and other associated administrative and logistical support facilities. The initial cost of the installation was approximately 60 million dollars including $250,000 for the land.

FIGURE I-2. ORGANIZATIONAL CHART

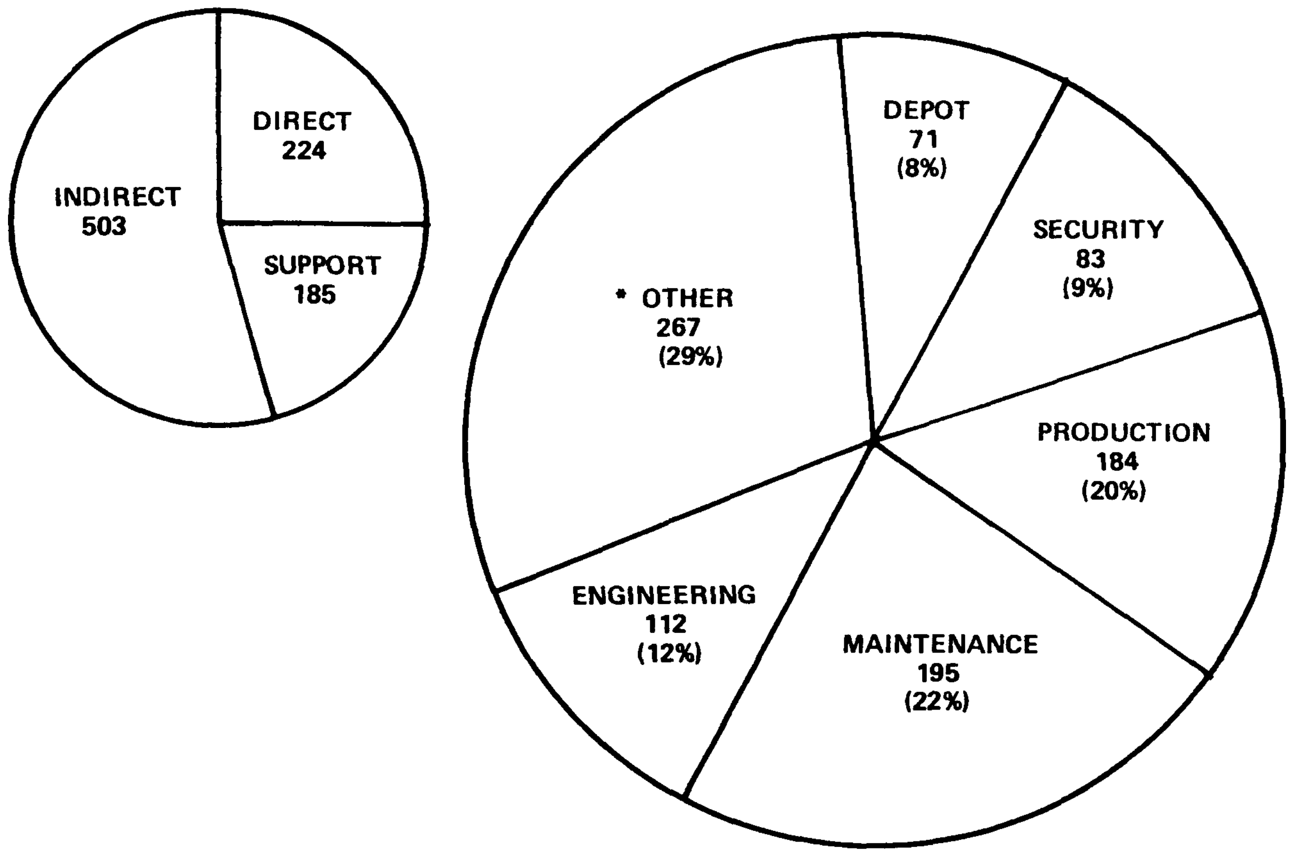
UNITED STATES ARMY ARMAMENT MATERIEL READINESS COMMAND
PINE BLUFF ARSENAL



PBA MANPOWER DISTRIBUTION
TDA AUTHORIZED STRENGTH, 912
1 OCTOBER 1976

* OTHER

PERSONNEL OFFICE
COMPTROLLER
PROCUREMENT
DATA PROCESSING
UTILITIES
FIRE PREVENTION
MOBILE EQUIPMENT
RAIL TRAFFIC



EMPLOYEES	
CIV	912
OFF	13
EM	47
	972

FIGURE I-3. MANPOWER DISTRIBUTION CHART

The Arsenal was redesignated as Pine Bluff Arsenal on 5 March 1942. The headquarters was moved from the city of Pine Bluff to Pine Bluff Arsenal on 1 April 1942.

Initial production at PBA began on 31 July 1942 with the production of the AN M14 incendiary grenade. The operations expanded rapidly through World War II years to include 24 different end items. The work performed included the production of bulk chemical agents and the filling of various chemical bombs (incendiary, smoke and other chemical munitions). Activities at the Arsenal during 1945 and the early 1950's were principally maintenance and renovation of chemical supplies and equipment, industrial mobilization planning, and demilitarization.

The Korean Conflict created an expansion of operations at PBA. A total of 38 different end items were produced during the Conflict including various grenades, smoke pots, canisters, white phosphorous, and FS shells.

In 1953 the facilities for biological warfare operations were completed at PBA and designated as the Production Development Laboratories. In 1957 the laboratories were made an integral part of the Arsenal and established as a mission element under the designation Directorate of Biological Operations (DBO).

During the 1950's excess facilities were leased in Area 5, Sections 3 and 4 to Diamond Alkali and Niagara Chemical Companies. The Diamond Alkali produced chlorine for use by Niagara which produced DDT and chlorobenzene in large quantities. Malathion and parathion were received at the Niagara site and blended into formulations.

Facilities for the production of CS munitions were added at PBA in 1961 and in 1962 the BZ munitions facility was completed. Additional facilities were added to the Biological Operations area in 1964 at a cost of over $25,000,000.

The Presidential Executive Order of 25 November 1969 announced the discontinuance of the US biological warfare (BW) effort and the production of BW munitions. The President also directed that all existing stocks of biological components and munitions be demilitarized and destroyed. The demilitarization of all inventories of antipersonnel biological agents and munitions was completed at Pine Bluff Arsenal in January 1972. These facilities were then declared excess and the real property was transferred to the Food and Drug Administration (FDA) on 1 May 1972. FDA presently operates them as the National Center for Toxicological Research (NCTR).

E. Environmental

1. Water Quality

a. Surface Water. PBA is located in the Arkansas River Basin. All of the surface drainage and wastewaters generally flow in a southeasterly direction into the Arkansas River (see Figure I-4). There are six major creeks and several small ones on the Arsenal. They are Eastwood Bayou, Triplett Creek, Tulley Creek, Hospital Creek, White Creek*, Production Area Creek, Warbritton Creek, and Caney Bayou.

Eastwood Bayou drains the northern area of the post including the old biological agent storage area and the NCTR. It empties directly into the Arkansas River. Triplett Creek (also called Phillips Creek) drains the largest area on post. It drains the Toxic Storage Yard, the chemical manufacturing area, and part of the storage depot before emptying into the Arkansas River. Tulley Creek and Tulley Lake drain part of the old chemical manufacturing area, the old chlorine plant site, and most of the storage depot. Normally, Tulley Creek empties into Yellow Lake, but during flooding it empties directly into the Arkansas River. Hospital Creek empties into Yellow Lake after draining the barrack, administration, and hospital area. White Creek drains the shop and white phosphorus production areas before emptying into Yellow Lake. Production Area Creek and Warbritton Creek drain the production area and bomb storage area. They both empty into the Arkansas River through the old river bed. Caney Bayou parallels the western boundary of PBA. Areas along this boundary and southern end of the Arsenal are drained by it and eventually empties into the Arkansas River after flowing through several small towns and Lake Pine Bluff. See Table I-1 below.

TABLE I-1. SIZE OF THE VARIOUS DRAINAGE SYSTEMS LOCATED ON PINE BLUFF ARSENAL

Drainage Area	Number of Acres
Eastwood Bayou	2,486
Triplett Creek	3,562
Tulley Creek	2,193
Hospital Creek	1,055
White Creek	760
Production Area Creek	1,030
Caney Bayou	1,757
Arkansas River	673
Old River Bottom	631
Yellow Lake	411
Warbritton Creek	518
Ponds	379

*Various references relate to the creeks name as: White Creek and White Phosphorus Creek.

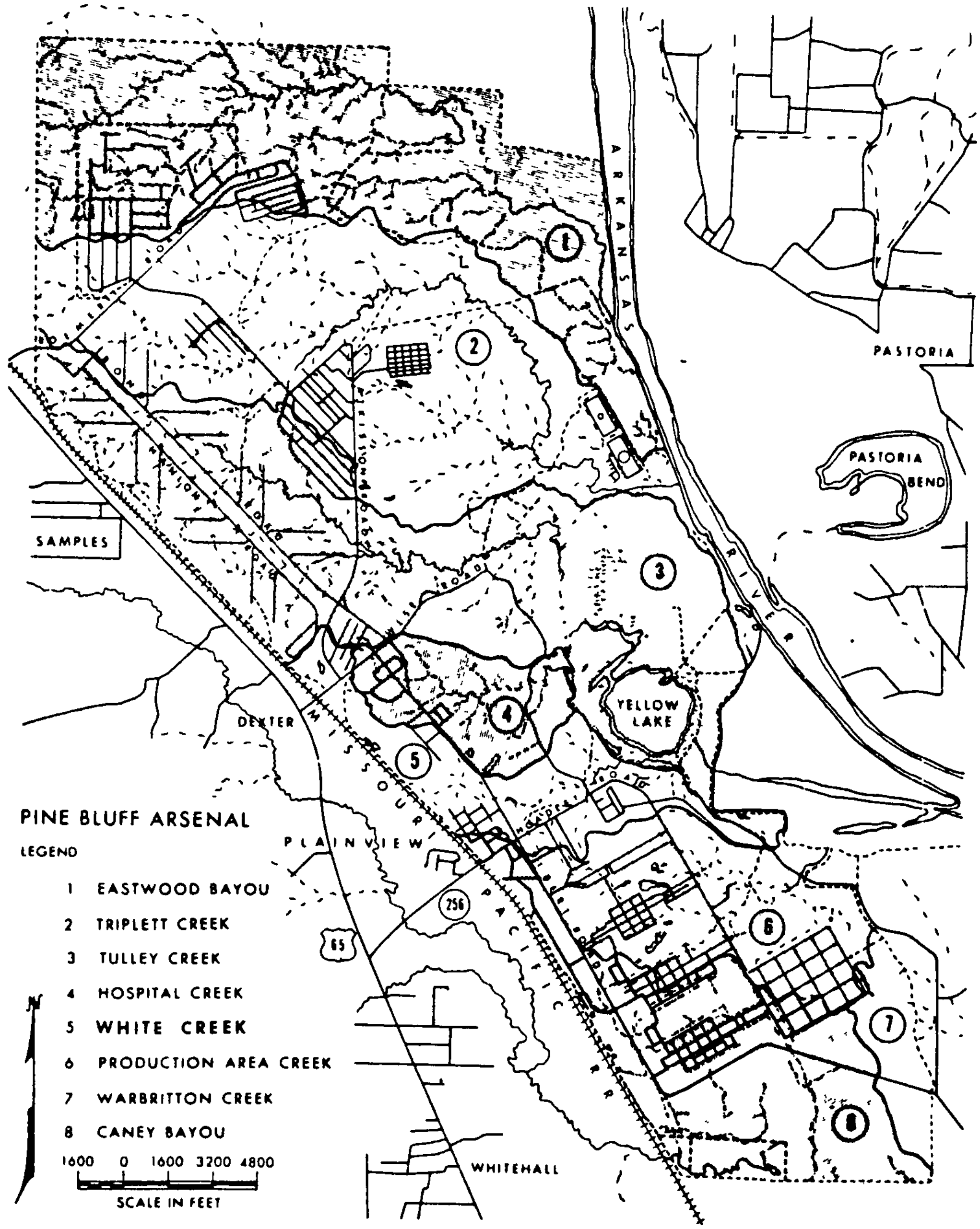


FIGURE I-4. DRAINAGE AREAS OF US ARMY PINE BLUFF ARSENAL, PINE BLUFF, ARKANSAS

Yellow Lake is located in the southeastern part of the post. Yellow Lake was formed as the result of an old meander of the Arkansas River being cut off during flooding sometime after 1936. Presently Yellow Lake is about 200 acres surrounded by trees and swampland. It receives backwaters from the Arkansas River during its high water stages. A list of the other small ponds and their acreage is included in Table I-2.

TABLE I-2. LIST OF SMALL PONDS

Name	Surface Acreage
Yellow Lake	200
Tulley Lake	35
Duck Reservoir (2)	10 each, 20 acres total
Clear Pond	2
Dilly Pond	3
Gibson Pond	2
Big Transportation Pond	2
Big Area 3 Pond	4
Grassy Pond	3
Arkla Pond	2
Bomb Storage Pond	1
Little Transportation Pond	1
Horseshoe Pond	1
Dexter Pond	1
Bunker Pond	1
King Pond	1
Thompson Pond	1

Twelve deep wells supply all water used at PBA. There are three separate distribution systems known as the Chemical Area system, the South (IBF) Area system, and the NCTR Area system. The Chemical Area system is an industrial water distribution system with no treatment. The other two are potable systems incorporating water treatment plants. The two treatment plants are shown in Figure I-5.

Water is supplied to the NCTR Area system from Well Numbers 14, 15, 16, 17, and 18. Location of these wells is shown in Figure I-5. Three types of water are produced by this treatment plant. After general treatment, the water is pumped to an industrial water (general distribution) storage tank. This water is used for firefighting and other industrial purposes. Water from the storage tank is chlorinated before being pumped to potable distribution systems for consumption. Water from the storage tank is also diverted through one of two demineralization processes prior to its distribution to the NCTR restricted area for research applications. The average production was 51,000 gallons per day from January to July 1972.

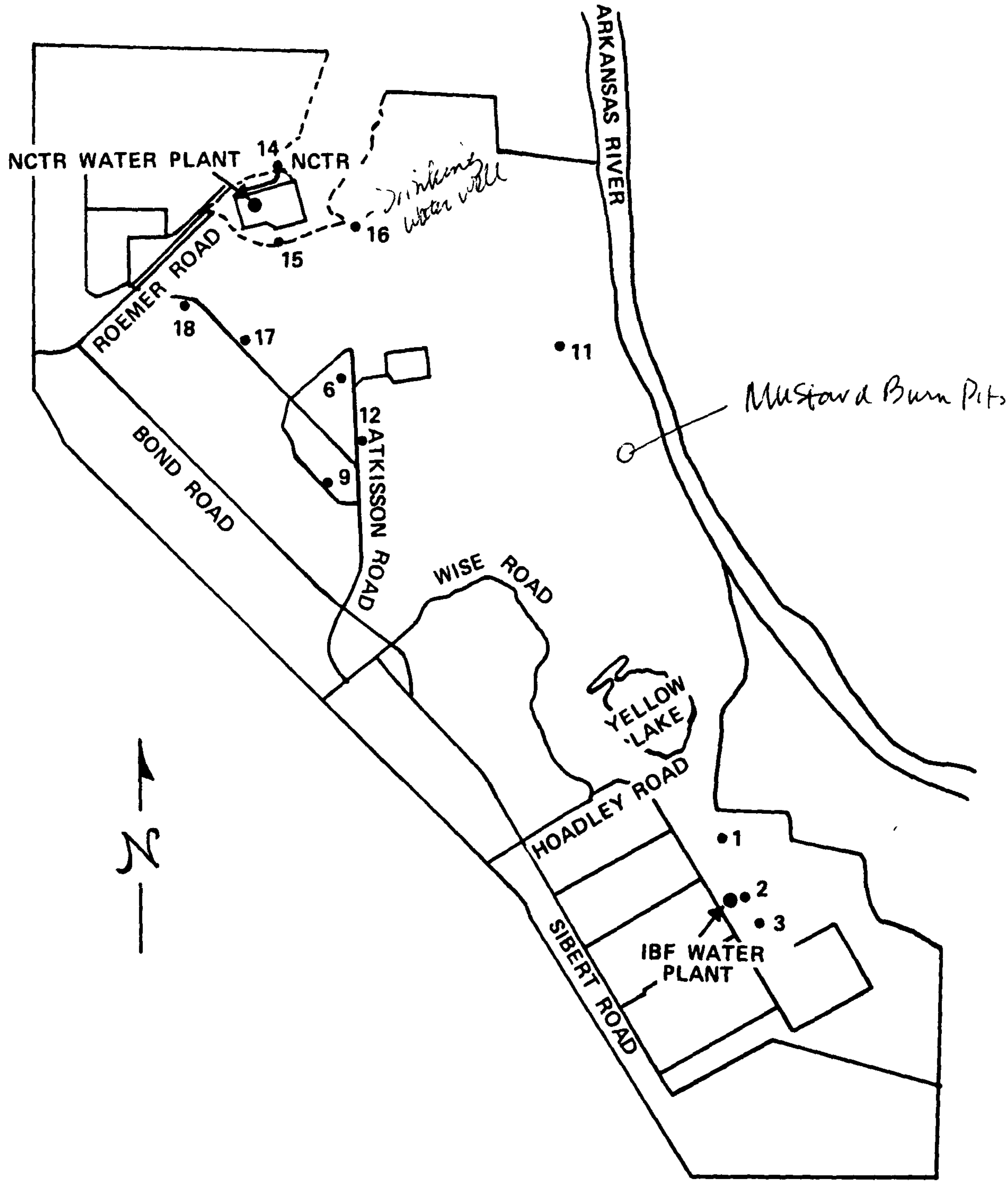


FIGURE I-5. LOCATION OF DEEP WATER WELLS AND WATER TREATMENT

The IBF water treatment system draws water from Wells 1, 2, and 3. Production averaged 75,000 gallons per day for the same six-month period in 1972. This system produces potable water for the post's administrative and production facilities after being subjected to the following processes: aeration over a coke tray, lime/alum chemical feed, sedimentation, anthrafilt pressure filtration, and chlorination.

The Chemical Area system supplied non-potable water for industrial purposes to the old Arkansas Louisiana Chemical Corporation (ARKLA Plant); it still serves the TSY and provides fire protection water for the Area 5 storage area. Water obtained from Wells 6, 9, 11 and 12 is pumped directly into the system without treatment and stored in three elevated 200,000 gallon steel tanks. Potable water is provided in the Chemical Area by a line from the IBF water treatment system. See Appendix C.

b. Subsurface Water. There are two significant aquifers in the PBA area: a shallow water table aquifer; and a confined aquifer tapped for water supply for PBA, industry, and the city of Pine Bluff. The shallow water table aquifer is formed by quaternary surface deposits. The water table is at 190 to 195 feet mean sea level (msl) elevation with an average depth to water of 45 feet. The flow of water in the water table aquifer is controlled by the permeability of the formation, elevation and stage of the Arkansas River, and location and amount of local recharge. Direction of flow is generally eastward to the Arkansas River at an estimated mean velocity of about 25 feet per year. This estimate could vary from slightly less to twice as much as the estimated value. There is some indication of a groundwater "ridge" in the southern portion of the manufacturing area. The high runs northeast to southwest. Groundwater flow off the southern flank of the high would be to the southeast towards an off-post area occupied by private owners. The recharge mode has not been identified. It would be from either wide-area infiltration through the soil or from stream channel influent seepage. Probably the bulk of the recharge is along stream channels with smaller amounts from surface infiltration. The water table aquifer is in hydraulic connection with the Arkansas River and ordinarily is effluent to it. During flooding there may be seepage from the river to the aquifer, but the river water would not penetrate more than 20 to 30 feet into the aquifer. A groundwater monitoring program was initiated in 1967. Table I-3 contains a description of the wells and the water levels in 1973 and 1976. Chemical analysis of the water is contained in Table I-4. The boring logs for these wells are presented in Appendix D. Logs for the deep water wells were also obtained and are included in Appendix D (see Figure I-6).

The confined aquifer known as the Sparta Sand is tapped by Arsenal wells at a depth of 800 to 1,000 feet. In the PBA area the Sparta Sand is not believed to be in hydraulic connection with surface water or shallow groundwater.

TABLE I-3. WATER LEVEL READINGS IN MONITORING WELLS

Well Numbers New	Old	Location	Depth Below Ground to Water Surface (Feet) 1972	1976
14-02-00	5	McCoy Road	48	42
14-02-01	6	North of Hoadley Road	51.5	47
31-02-00	13	Avenue 311A at 317th St.	38.8	32
31-02-01	14	Avenue 314B at 314th St.	40	34
31-02-02	15	Avenue 311B at 310th St.	38.5	32
32-02-00	11	Avenue 321A at 328th St.	41.7	35
32-02-01	12	328th St. near Bldg 32-690	41.7	36
33-02-00	9	338th St. near Avenue 331A	43.2	36
33-02-01	10	332B Avenue near Bldg 33-670	43.2	35
33-02-02+	16	Sibert Road	46.8	40
34-02-00	7	Off Stokes Road near Avenue 34B	46	40
42-02-00	8	On Stokes Road	43	36
54-02-00*	3	Between Bldg 53-110 and 53-220	185.5	183
56-02-00	4	Webster Road	50	42
74-02-00+	17	Near McCoy Road	50.5	42

+Existing wells rehabilitated.

*Drilled to 685 feet to reach water. This was done by PBA in an attempt to prove the absence of useful groundwater for monitoring in the old ARKLA area.

NOTE: Wells 1 and 2 were drilled to 135 and 100 feet respectively without evidence of water. They were abandoned as dry holes.

TABLE I-4. VALUES FOR GROUNDWATER MONITORING SYSTEM
JANUARY 1971 TO MARCH 1972

Constituents - mg/l

Well No. New No.	Old No.		pH	Suspended Residue	Total Residue	Filterable Residue	Chloride	Sulfate	Nitrate	Zinc	Total Phosphate	Filtered Phosphate	COD
14-02-00	5	Range	6.2-7.0	0-12	15-314	14-306	9-98	3-239	0-14	.8-1.1	0-.01	0-0	16-64
		Ave.		4	190	186	70	52	3	.57	0	0	26
14-02-01	6	Range	6.5-7.2	0-4	58-274	54-272	7-69	2-300	0-13	.03-2.0	0-.01	0-0	9-352
		Ave.	6.9	2	188	174	46	51	2	.59	0	0	71
31-02-00	13	Range	5.9-6.8	0-9	57-406	57-404	3-166	4-140	0-14	.54-.97	0-0	0-0	4-116
		Ave.	6.2	4	131	127	39	36	3	.72	0	0	35
31-02-01	14	Range	5.7-6.7	0-12	18-70	18-68	2-12	3-53	0-24	.61-1.1	0-0	0-0	0-104
		Ave.	6.0	3	45	42	7	14	5	.89	0	0	30
31-02-02	15	Range	5.6-7.0	1-6	2-96	0-92	2-12	3-111	0-15	.66-1.3	0-0	0-0	0-72
		Ave.	6.0	3	55	52	7	24	6	.97	0	0	29
32-02-00	11	Range	5.7-6.7	0-9	82-256	76-250	5-94	0-49	0-6	.83-1.2	0-0	0-0	9-84
		Ave.	6.0	4	165	161	60	10	2	.96	0	0	38
32-02-01	12	Range	5.9-6.8	2-16	32-106	26-100	2-15	3-82	0-7	.43-1.2	0-0	0-0	9-90
		Ave.	6.3	7	67	59	9	18	2	.92	0	0	53
33-02-00	9	Range	5.7-6.8	2-8	48-158	46-154	4-65	3-95	0-3	.47-2.0	0-0	0-0	4-104
		Ave.	6.0	4	108	103	35	16	1	1.3	0	0	36
33-02-01	10	Range	5.8-6.9	8-14	42-142	34-134	4-40	1-78	0-6	.33-1.9	0-0	0-0	0-152
		Ave.	6.2	9	99	89	25	16	2	1.1	0	0	41
33-02-02	16	Range	6.4-6.8	2-12	100-212	98-210	5-54	4-41	0-17	.50-.82	0-.01	0-.01	0-104
		Ave.	6.5	4	155	151	34	12	4	.65	.01	0	28
34-02-00	7	Range	6.3-7.4	0-13	60-144	56-140	2-22	2-70	0-11	.25-1.2	0- 01	0-0	9-116
		Ave.	6.6	5	103	97	14	17	2	.92	0	0	42
42-02-00	8	Range	6.1-7.0	2-17	53-246	36-242	3-66	0-62	0-3	.35-3.2	0-0	0-0	0-64
		Ave.	6.4	6	114	107	23	16	1	1.7	0	0	23
54-02-00	3	Range	6.2-7.0	2-14	34-456	30-454	1-11	4-25	0-7	.15-1.2	0-0	0-0	0-28
		Ave.	6.5	6	125	119	6	13	1	.75	0	0	18
56-02-00	4	Range	6.1-6.4	2-18	142-798	136-792	17-173	2-335	0-13	.20-2.9	0-.01	0-0	9-38
		Ave.	6.2	7	442	434	97	157	4	1.1	0	0	24
74-02-00	17	Range	6.0-6.8	1-10	29-690	28-686	12-166	3-658	0-24	.12-1.3	0-0	0-0	4-37
		Ave.	6.2	4	326	322	99	173	6	.59	0	0	27

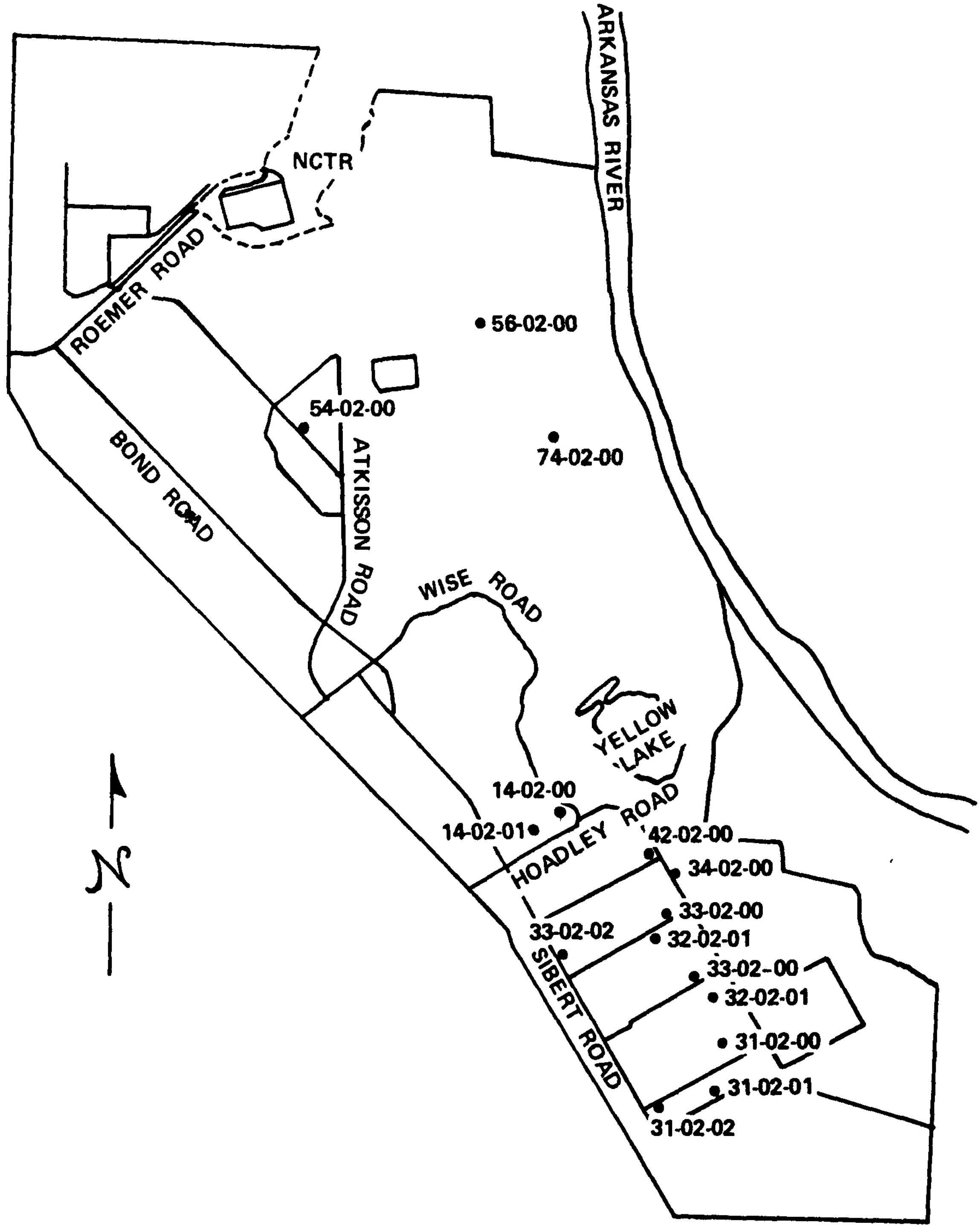


FIGURE I-6. LOCATION OF WATER QUALITY MONITORING WELLS

2. Natural Resources

a. Fauna. Terrestrial ecological surveys of PBA made by the Ecology Branch, Environmental Technology Division of Chemical Systems Laboratory, have indicated that most of the biological communities are healthy and normal.

(1) Mammals. There are 35 species of mammals known to occur at PBA. The most common species are the white-tailed deer, cotton rat, white-footed mouse, and the fox squirrel. These and other mammals are listed in Appendixes E and F. There have been reports, but no capture records, of an endangered species -- the Mississippi Valley red wolf (Canis rufus gregori).

(2) Birds. One hundred fifty-six species of birds have been recorded on the Arsenal. Two species, bobwhite and turkey, are upland game birds. A species list of birds is included in Appendix E. Two endangered species, the peregrine falcon (Falco peregrinus) and the red-cockaded woodpecker (Dendrocopus borealis) have been reported. The falcons were located in the wetlands of PBA. The woodpeckers were sighted in 1965. A ten acre tract of pines was set aside around the nest-site trees, but no sightings of the birds have been made since 1966.

(3) Fishes. Appendix E includes the fishes known to be on or near PBA. This is not a complete list as the creeks and streams have never been adequately surveyed.

(4) Reptiles and Amphibians. Fifty-nine amphibian and three reptile species have been recorded. They are listed in Appendix E.

(5) Invertebrates. A list of invertebrate taxa collected in streams on PBA is given in Appendix E.

b. Flora. The natural resources program claims 14,000 of the 15,000 acres in PBA. The remaining land is occupied by buildings, roads, railroads, parking and storage areas, walks, and pavements. Ten thousand acres are considered improved land, which includes 8,000 acres involved in timber stand improvement, 1,200 acres in erosion control programs, 600 acres of cleared land, 300 acres under weed control, and 200 acres of planted trees.

PBA is located on the border of two major climax situations in Jefferson County. Initially, the land was mostly forest; however, most of the timber had been cut prior to government acquisition in 1941. Presently 80% of the forested areas are in pine, resembling the pine-oak-hickory climax of the southwestern half of Jefferson County. In areas where all the trees have been removed, the main vegetation is bermuda grass, broomsedge, lespedeza, hop clover, dallisgrass, crabgrass, and needlegrass. Johnson grass is abundant in open areas in the bottoms and along the Arkansas River. A list of vegetation found at PBA is contained in Appendix E.

3. Geological Resources

a. Physiography/Topography. PBA occupies a level alluvial terrace overlooking the Arkansas River in the west central portion of the Mississippi Embayment. The local relief of the terrace is less than 20 feet, except where surface streams have cut to a depth of 20 feet in some locations. A 30 to 50 foot high north-south bluff bounds the terrace on the east. Total relief on PBA is 150 feet from an elevation of 190 feet msl at the Arkansas River to an elevation of 340 feet msl in the northwestern portion.

b. Geologic Formations. Unconsolidated formations which outcrop on PBA are: quaternary alluvium deposited by the aggrading Arkansas River that occupies the narrow flood plain below the bluff and around Yellow Lake and quaternary terrace deposits underlying the bulk of PBA located above the bluff (see Figure I-7). Outcropping on the northwest and possibly along the western boundary are shales, muds, and sands of the Jackson Group. The surface cut on the Jackson Group is at a higher elevation with more local relief than the terrace surface. Paleozoic bedrock lies about 3,000 feet below the surface. Table I-5 shows the geologic section for PBA and vicinity. See also Appendix G.

TABLE I-5

Formation Name	Age	Remarks
Alluvium Terrace Deposits	Quaternary	Unconsolidated, water bearing
Jackson Group undifferentiated	Eocene	Largely impermeable, minor water in thin sands
Clairborne Group Cockfield formation Cook Mountain formation Sparta Sand . . .	Eocene	 Water bearing
Older deposits	Paleozoic bedrock	

c. Soils. Surface soils at PBA range from clays, silts, to silty sands depending upon the environment of deposition. All types of material can be encountered at some depth in the subsurface although they are primarily silts, sandy silts, and clays (see Figure I-8).

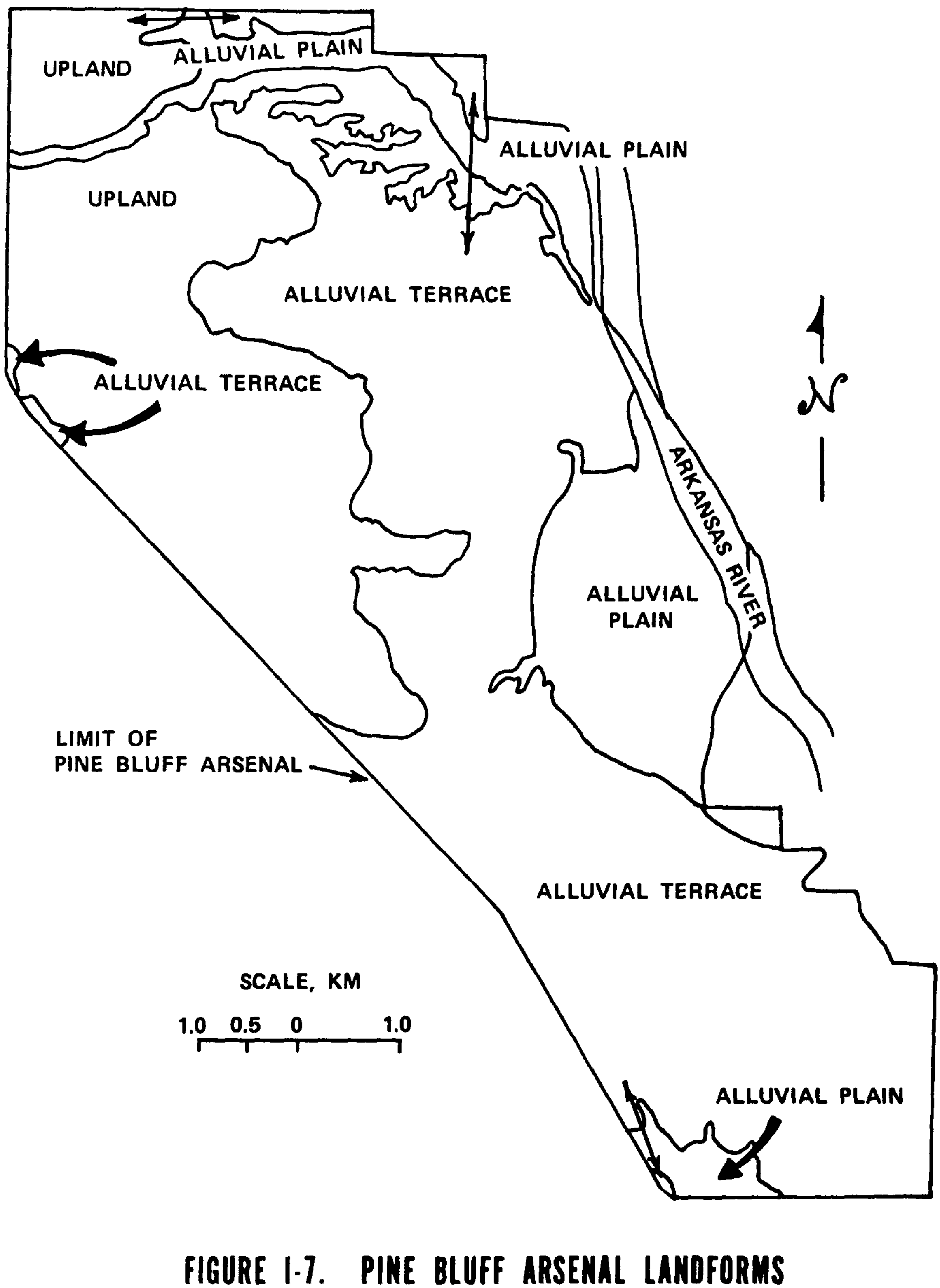
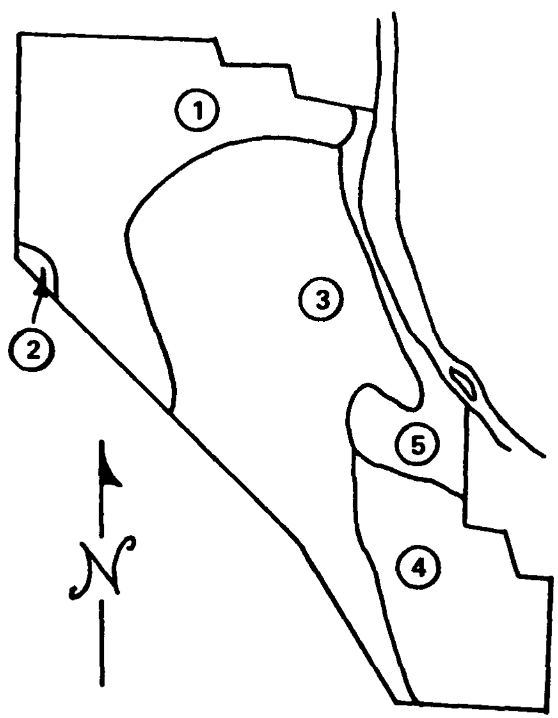


FIGURE I-7. PINE BLUFF ARSENAL LANDFORMS



PINE BLUFF ARSENAL LEGEND:

1. ANGIE-SACUL (SAFFEL) – SAVANNAH
2. CAHABA-SAVANNAH
3. AMY-PHEBA-SAVANNAH
4. HENRY-CALLOWAY GRENADA
5. CREVASSE-PORTLAND

FIGURE I-8. SOILS TYPE MAP

There are five soil associations on PBA. The Angie-Sacul (Saffel)-Savannah association is located on the northern end of PBA. These soils are deep, moderately well drained, slowly and moderately slowly permeable, acid, and loamy. They consist of 35% Angie, 25% Sacul, 25% Savannah, and 15% inclusions of Amy, Ochlockonee, Iuka, Myatt, Cahaba, Susquehanna, and Pheba. Angie soils have grayish-brown fine sandy loam surface soil over yellowish-brown silty clay loam upper subsoil. Sacul soils have grayish-brown fine sandy loam surface soil over yellowish-red or red clay subsoil that is mottled gray in the lower part. Savannah soils have grayish-brown fine sandy loam surface soil over yellowish-brown loam or sandy clay loam subsoil that has a gray, yellow, and brown mottled fragipan in the lower part.

The Cahaba-Savannah association occupies a small niche on the western boundary of PBA. It is deep, well and moderately well drained, moderately and moderately slowly permeable, acid, and loamy. They consist of 45% Cahaba, 40% Savannah, and 15% inclusions of Angie, Amy, Pheba, and Sacul. The well-drained Cahaba soils have grayish-brown or brown fine sandy loam surface soil over yellowish-red or red sandy loam or sandy clay loam subsoil. The moderately well drained Savannah soils have already been described.

The Amy-Pheba-Savannah association occupies the central part of the Arsenal. These soils are deep, poorly to moderately well drained, slowly and moderately slowly permeable, acid, and loamy. They consist of 45% Amy, 25% Pheba, 20% Savannah, and 10% inclusions of Myatt, Cahaba, Angie, Sacul, and Ochlackonee. The poorly drained Amy soils have gray silt loam surface soil over gray, mottled silt loam or silty clay loam subsoil. The somewhat poorly drained Pheba soils have dark gray to grayish-brown silt loam or loam subsoil that has a fragipan in the lower part.

The Henry-Calloway-Grenada association lies on the southern end of PBA. These soils are deep, poorly to moderately well drained, slowly permeable, level to gently sloping, acid, and loamy. This association is made up of 40% Henry, 40% Calloway, 15% Grenada, and 5% inclusions of Falaya and Zachary soils, and gullied land. The poorly drained Henry soils have grayish brown or gray silt loam surface soil over gray, mottled silt loam or silty clay subsoil that has a fragipan. The somewhat poorly drained Calloway soils have grayish-brown silt loam or silty clay loam subsoil that has a fragipan. The moderately well drained Grenada soils have brown silt loam or silty clay loam upper subsoil and mottled gray and yellowish-brown lower subsoil that is a fragipan.

The Crevasse-Portland association occupies an area around Yellow Lake and a narrow strip running north along the east edge of the Arsenal. These soils are deep, somewhat poorly drained, rapidly to very slowly permeable, and acid to neutral in pH. The sandy and clayey bottom land soils are subject to frequent flooding. The association consists of 45% Crevasse, 30% Portland, and 25% inclusions of Rilla, Keo, Morgenfield, Latanier, Desha, and Perry. The excessively drained Crevasse soils have brown loamy sand surface soil overlying light yellowish-brown sand. The somewhat poorly drained Portland soils have dark grayish-brown silty clay loam to clay surface soil over dark brown to red, mottled clay subsoil.

II. CONTAMINATION ASSESSMENT

A. Industrial Operations

1. Historical Background

In 1941, Pine Bluff Arsenal was established for the manufacturing, loading, and assembly of various incendiary and chemical munitions. The original mission of loading magnesium and thermite types of incendiary bombs was expanded through the years to include the manufacture of agent, filling of chemical bombs, incendiary smoke munitions, and the filling of various munitions with chlorine, mustard and lewisite.

During the Korean War PBA produced incendiary bombs and clusters, smoke grenades, smoke pots and canisters, white phosphorus and FS shells (sulfur trioxide - chlorosulfonic acid solutions). Biological warfare operations were started in 1953. In 1961 a CS munition production facility was completed and in 1962 a BZ munition facility was put in operation. Appendixes H and I contain lists of buildings at PBA.*

2. Production Operations

Production at PBA can be grouped into three main categories: (1) Pyrotechnics (formerly incendiary), (2) Chemical manufacturing, and (3) Biological operations. These production categories are identified on Figure II-2.

a. Pyrotechnic Area. The pyrotechnic area is located in area 3, sections 1, 2, 3, and 4. Sections 1 through 3 are similar in layout; there are two plant units and each has two production lines. Colored smokes (red, yellow, green, and violet), M36 cluster, and CS facilities are scattered throughout the three sections. Primary facilities for handling colored smoke are buildings 33-530 and 33-630 which are used for filling/pressing of grenades and canisters, respectively. Other operations such as mixing, drying, storage, etc. are scattered throughout sections 1 through 3. The primary facility for handling the M36 cluster is building 33-530 wherein pressing, assembly, leak-test, and packout operations occur. Primary facilities for CS are buildings 31-630 and 32-640 for grenades and canisters, respectively. Other operations involving CS (mixing, drying, etc.) and the M36 cluster (mixing, primer/firing pin subassembly, etc.) are scattered throughout the three sections. Note: The M36 cluster facility was removed from Building 33-530 in 1972. No M36 cluster facilites are presently at PBA.

*The process of locating individual facilities or buildings has been greatly simplified at PBA. Arsenal lands have been divided into numbered areas which are themselves subdivided into numbered sections. Each structure is then numbered to identify the area/section in which it lies. For example, building 31-630 is located in area 3, section 1, etc. (See Figure II-1.)

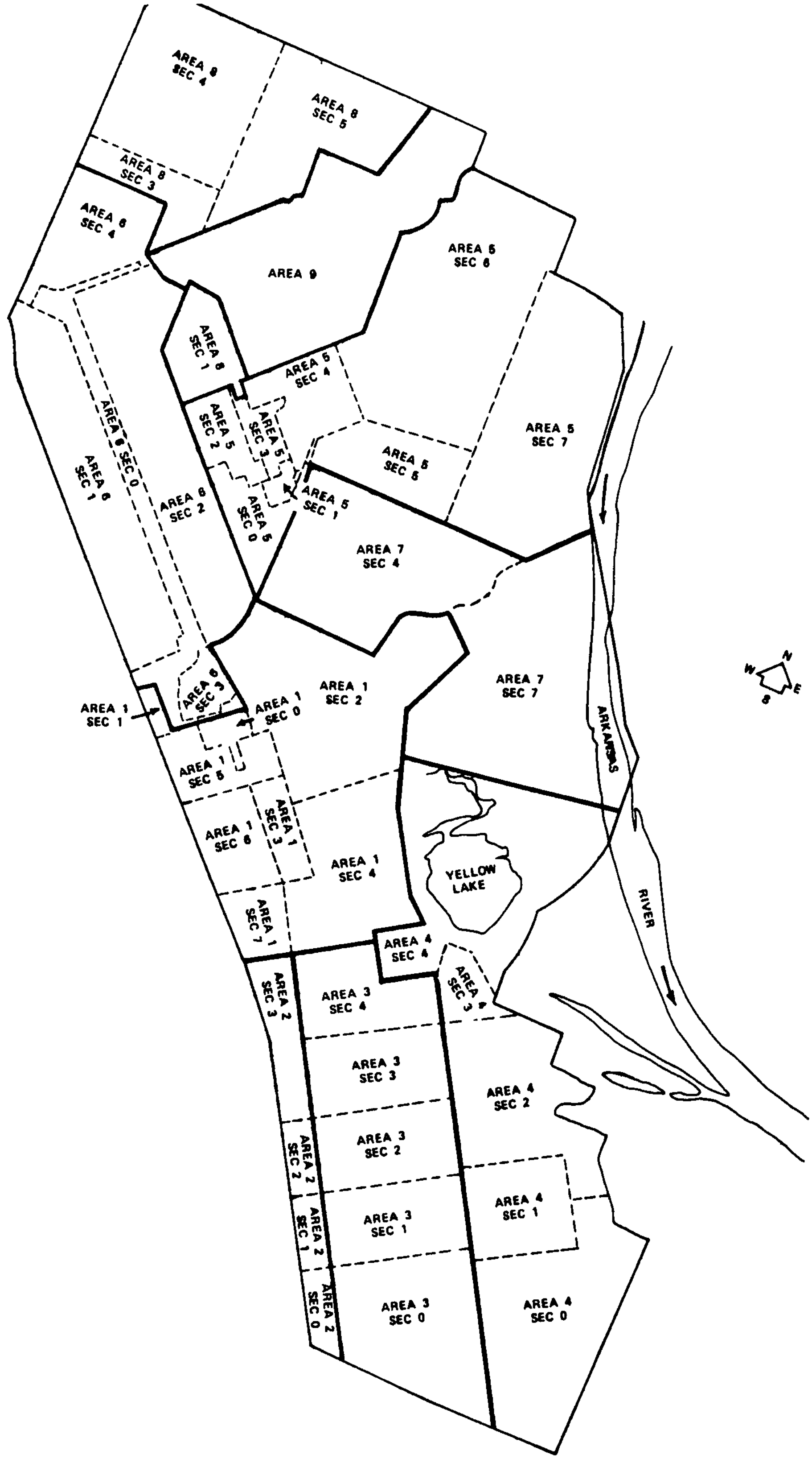


FIGURE II-1 AREAS AND SECTIONS OF PINE BLUFF ARSENAL

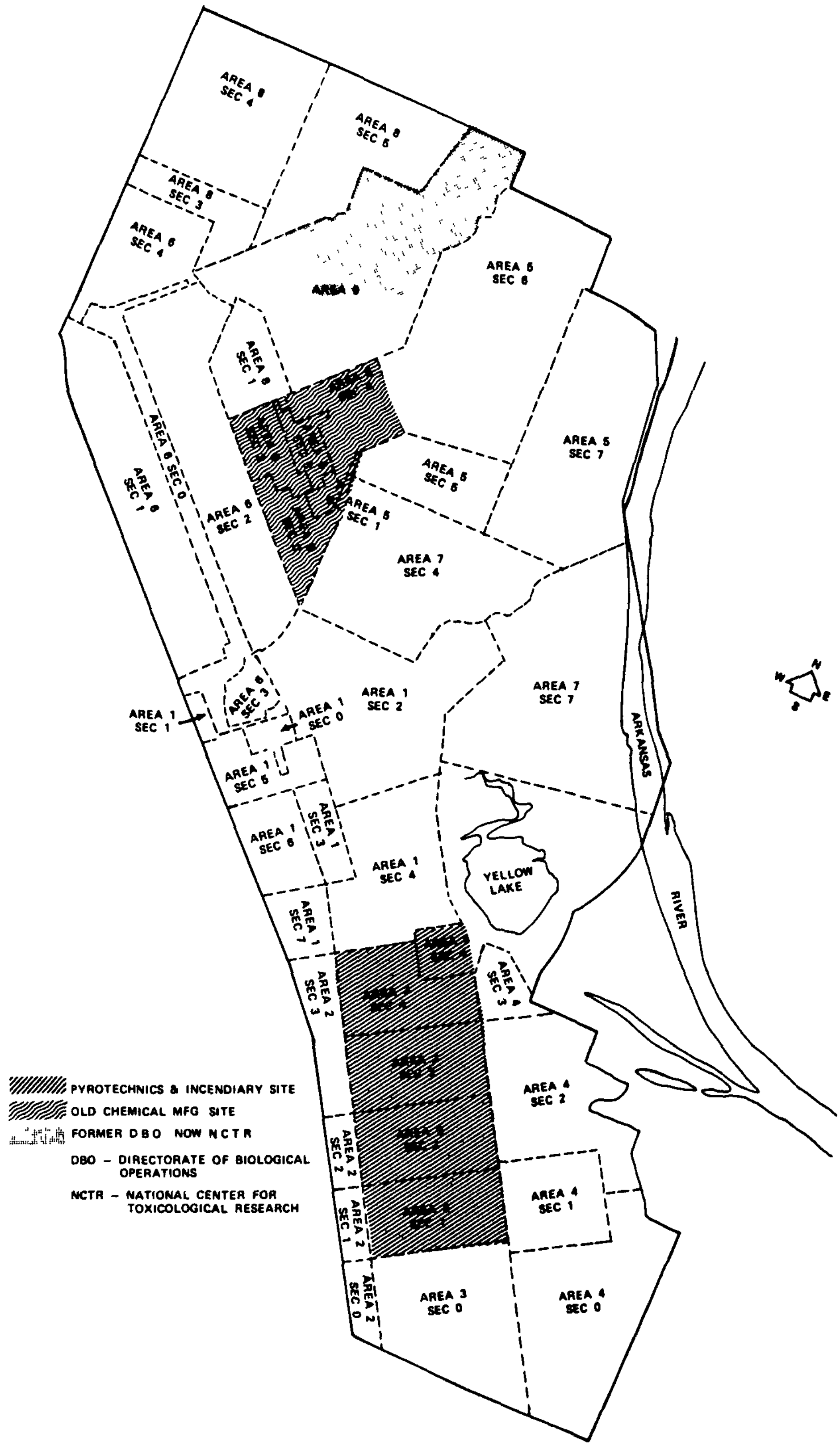


FIGURE II-2. FORMER PRODUCTION SITES AT PBA

The HC smoke (white smoke) production area is located at the north end of the pyrotechnic area. Facilities are buildings 34-340 through 34-680 and consist of five production buildings and two support structures. Building 34-630, the primary building, has the capability to fill/press smoke pots. Building 34-860 is a storage igloo in the original HC smoke area.

Production facilities for the TPA-filled M74 rocket clip are concentrated in a minor portion of area 3, section 1. Primary facilities are building 31-540 for the fuze/clip subassembly operation and building 31-640 for fill/load assembly pack (LAP).

Former BZ production facilities are fenced off from other buildings. Primary facilities are building 32-530 for filling, loading, assembly, and packout and building 32-540 for agent production. Equipment for BZ production has been decontaminated and buried at the PBA landfill.

Building 32-070 was converted into a facility to impregnate clothing worn by personnel subject to exposure by chemical agents. The building was formerly a tool and die machine shop. Articles of clothing are treated in an aqueous suspension of polyvinyl alcohol, chlorinated paraffin, and biphenyl dichloro urea. A waste treatment study on this facility by AEHA, Report No. 24-044-73/76, dated 13 February - 21 March 1974, is included as Appendix J.

Buildings 34-101 through 34-220 constitute the WP filling facilities. Three wet fill lines and one dry fill line, empty/filled shell, inspection/packout, and demilitarization/rework areas are located in building 34-110, the primary building. Oven-testing as a phosphorus leak check is performed north of Building 34-110 in steam heated ovens. Some of the items filled in these facilities prior to 1974 are listed in Table II-1. A typical years production for 1972 is listed in Table II-2.

TABLE II-1. ITEMS FILLED IN WP FILLING FACILITIES PRIOR TO 1974

Items Filled on Wet Lines	Items Filled on Dry Line
Grenade, M34	Warhead, Rocket, 2.75 inch, M156
Bomb, BLU-17/P, WP	Cartridge, 60-mm, M302
Cartridge, 60-mm, M302	Cartridge, 81-mm, M375
Igniter, AN-M23A1	Cartridge, 4.2 inch, M328
Warhead, Rocket, 2.75 inch, M156 & XM67	Cartridge, 105-mm, M60 and M416
Cartridge, 105-mm, M60E1 and M416	
Cartridge, 4.2 inch, M348A1	
Projectile, 5 inch, MK-14 and M5	
Projectile, 155-mm, M110	
Projectile, 175-mm, XM510E2	
Launcher, CBU-12 and CBU-22	

TABLE II-2. SUMMARY OF MUNITION QUANTITY/QUALITY FOR FY 1972
AN OUTPUT LIST FOR A TYPICAL PRODUCTION YEAR

End Item Description	Net Quantity Produced	No. Lots	No. Lots Temp/Perm Rejected	Inprocess Rejects
Bomblet, INC, M126	2,421,183	76	--	18,888
Cluster, M36E2	13,498	77	--	--
Canister, 105mm, CS, XM8	141,839	22	--	2,183
Grenade, AN-M8	189,867	26	--	7,460
Grenade, Colored Smoke, M18	408,800	53	5	635
Grenade, M18 Green	216,056	31	1	1,082
Grenade, M18 Red	125,344	13	--	224
Grenade, M18 Violet	288,831	30	1	1,054
Grenade, M18 Yellow	557,739	62	1	1,797
Grenade, M34	21,888	1	--	61
Igniter, AN-M23A1	108,888	8	--	135
Projectile, 57mm, WP	26,156	2	--	41
Projectile, 81mm, WP	65,700	1	--	59
Projectile, 81mm, M375	24,894	4	--	288
Projectile, MK14, MOD 0	2,424	4	--	5
Starter, Fire, NP3, M2	1,250	1	--	2
Warhead, 2.75", WP	194,994	8	--	746
LAP Ctg, 81mm, M375	43,296	1	--	85
LAP Warhead, 2.75", w/Fuze, M423	2,453	1	--	--
LAP Warhead, 2.75", w/Fuze, M427	319,668	32	--	1
LAP Projectile, 81mm, M375, WP	27,076	2	--	--
LAP Rocket, 2.75", w/Warhead	2,453	2	--	--
Miscellaneous	15,830	147	--	--
TOTAL/YEAR	5,220,127	604	8	34,746

White phosphorus LAP facilities include buildings 44-100 through 44-121. The primary building (44-110) is able to receive WP filled items and to perform reworking, storage, maintenance, and assembly/packout operations.

b. Chemical Manufacturing Area. Mustard (H) and lewisite (L) manufacturing and filling operations were conducted in area 5, the chemical manufacturing area, from 1942 through December 1943.

In support of the mustard and lewisite operations, facilities for manufacturing chlorine and arsenic trichloride were constructed and operated from late 1942 until late 1943. Table II-3, obtained from historical records of PBA, shows amounts of materials produced through December 1943.

TABLE II-3. ACCUMULATIVE PRODUCTION FIGURES TO DECEMBER 1943

Mustard (H)	11,300 tons
Lewisite (L)	6,800 tons
Nitrogen Mustard HN-1	65 tons
Chlorine	13,500 tons
50% caustic	13,500 ttons
M47A2 Bombs filled with H	215,581 each
M70 Bombs filled with H	120,000 each
M70 Bombs filled with L	128,750 each
4.2 inch shells filled with H	40,400 each

The original complex contained 168 buildings/structures (see Figure II-3). These facilities remained idle until about 1950 when Diamond Alkali and Chemical Company and ARK-LA Chemical Corporation leased the old chlorine manufacturing facilities, a boiler house, and warehouse space for storage of chlorine manufactured until November 1969 (Area 5, Sections 2 and 3). Pine Bluff Chemical Company (later Niagara Chemical Company) leased several buildings to manufacture DDT and chlorobenzene for commercial agricultural pesticides using the chlorine (Area 5, Section 4). The former mustard manufacturing facilities have been declared excess and many of the buildings removed. Facilities retained include: (1) building 53-220 and pit 53-225 to be used for the proposed Binary Munitions Facility; (2) tanks 53-150, 53-250, 53-350, and 53-450 for the proposed Bulk Mustard Disposal Facility; (3) ten buildings/structures for present/future use. Included in the latter group is the former H filling building (53-990) which is presently used for storage by the Directorate of Depot Operations. Excessed buildings still standing include two small buildings and a cafeteria. The former L production facilities have been declared excess. Buildings 54-140, 54-240, 54-340, and 54-440 (three-story concrete and tile construction) were the primary facilities for lewisite production. Building 54-340 was also used to produce nitrogen mustard for a short period of time. The buildings cannot be disposed of by the Corps of Engineers because the removal cost is greater than the salvage value and potential contamination. Building remaining from

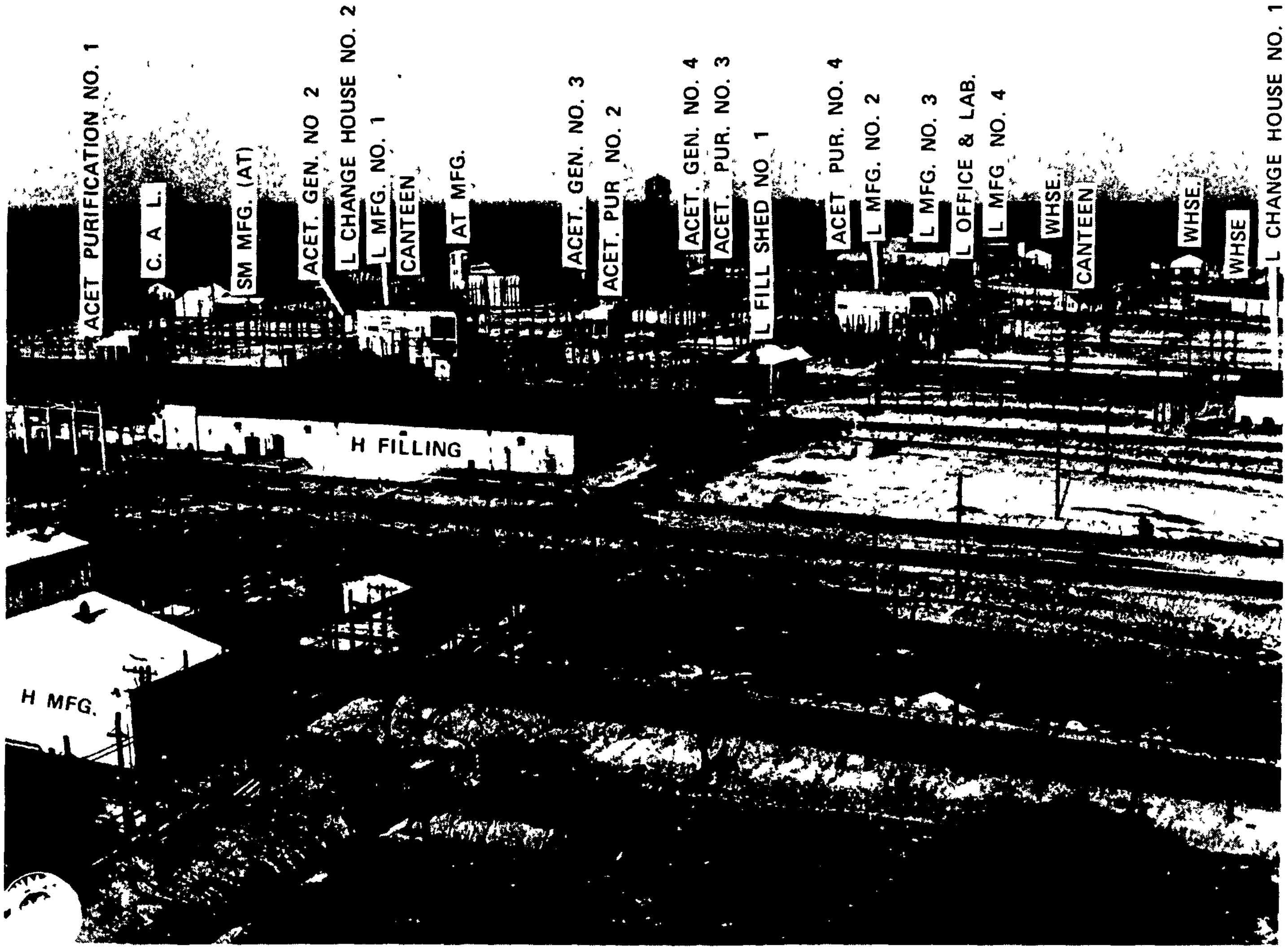


FIGURE II–3 PANORAMA VIEW FROM WEST WATER TOWER IN AREA 5, LOOKING NORTHEAST SHOWING "H" FILLING BUILDING AND ALL BUILDINGS OF "L" SECTION (H–MUSTARD/L–LEWISITE), 12/4/43.

the H and L facilities (see Figures II-4, II-5, II-6, and II-7) and their surrounding lands are known or suspected of being contaminated with DDT and arsenic as well as H and L and have been placed "off-limits." Building 54-140 (one of the L buildings) was leased during the 1950's by Niagara Chemical Company for DDT production, an operation that led to widespread contamination of facilities and grounds with DDT. The foundations of buildings 54-270 and 54-325 were retained for storage of DDT contaminated soil and other wastes. See Figure II-8.

c. Biological Operations. Biological operations including agent fermentation, munitions filling/production, and laboratory support were conducted in area 9 at PBA. Some of the biological warfare materials produced between 1954 and 1967 included Brucella suis, Pasteurella tularensis, Bacillus anthracis, Botulinum toxin, Staphylococcal enterotoxin, Clostridium botulinum toxin, and coxiella burnetii. Bulk agents along with antipersonnel munitions filled with these agents and toxins were stored at the Directorate of Biological Operations (DBO). Igloos utilized to store biological materials were identified as numbers 85-010, 85-030, and 85-040. The operations of the DBO were terminated in November 1969. During 1971 all stocks of biological munitions, agents, and toxins were destroyed in accordance with approved demilitarization plans. The DBO facility was decontaminated and deactivated and in 1972 the entire complex of land, buildings, and equipment was turned over to the Food and Drug Administration who now operates it as the National Center for Toxicological Research (NCTR). NCTR is operated separately from PBA. Waste generated by the Center is monitored by NPDES permits. NCTR operations were outside the scope of this records search.

3. By-product Waste and Contamination

It is possible that each of the production areas has contributed extensively to the contamination of PBA. Personnel on the Arsenal have compiled a list of suspected contaminated sites including drainage ditches. See Appendix I (Environmental Assessment Report). Suspected contaminants, site locations, and periods of active contamination are provided in Figure II-10. Several additional areas/sources of suspected contamination identified during the Team survey are shown in Figure II-9. In the pyrotechnic area, a significant amount of material was lost during preparation and transfer of mixes and during the pressing and sealing of canisters. During clean-up operations, accumulated mixes were flushed into the drainage systems and subsequently into drainage ditches which ultimately discharge into other ditches that cross private property en route to the Arkansas River (see Appendix K, AEHA Report 24-002-73, dated 17 - 21 July 1972). During an eight-hour shift it is estimated that 117,000 gallons of waste water is discharged when all buildings are in operation. The pyrotechnic area is drained by Warbritton Creek and the Production Area Creek. There are 22 drainage ditches in areas 3 and 4 which have been identified by PBA as being contaminated. Figure II-10, item 32, identifies contaminated areas. A list of potential pollutants from the pyrotechnic complex is provided in Table II-4.

FIGURE II–4 PANORAMIC VIEW OF MUSTARD FILLING AND LEWISITE MANUFACTURING BUILDINGS 12/2/43

FIGURE II–4 PANORAMIC VIEW OF MUSTARD FILLING AND LEWISITE MANUFACTURING BUILDINGS 12/2/43

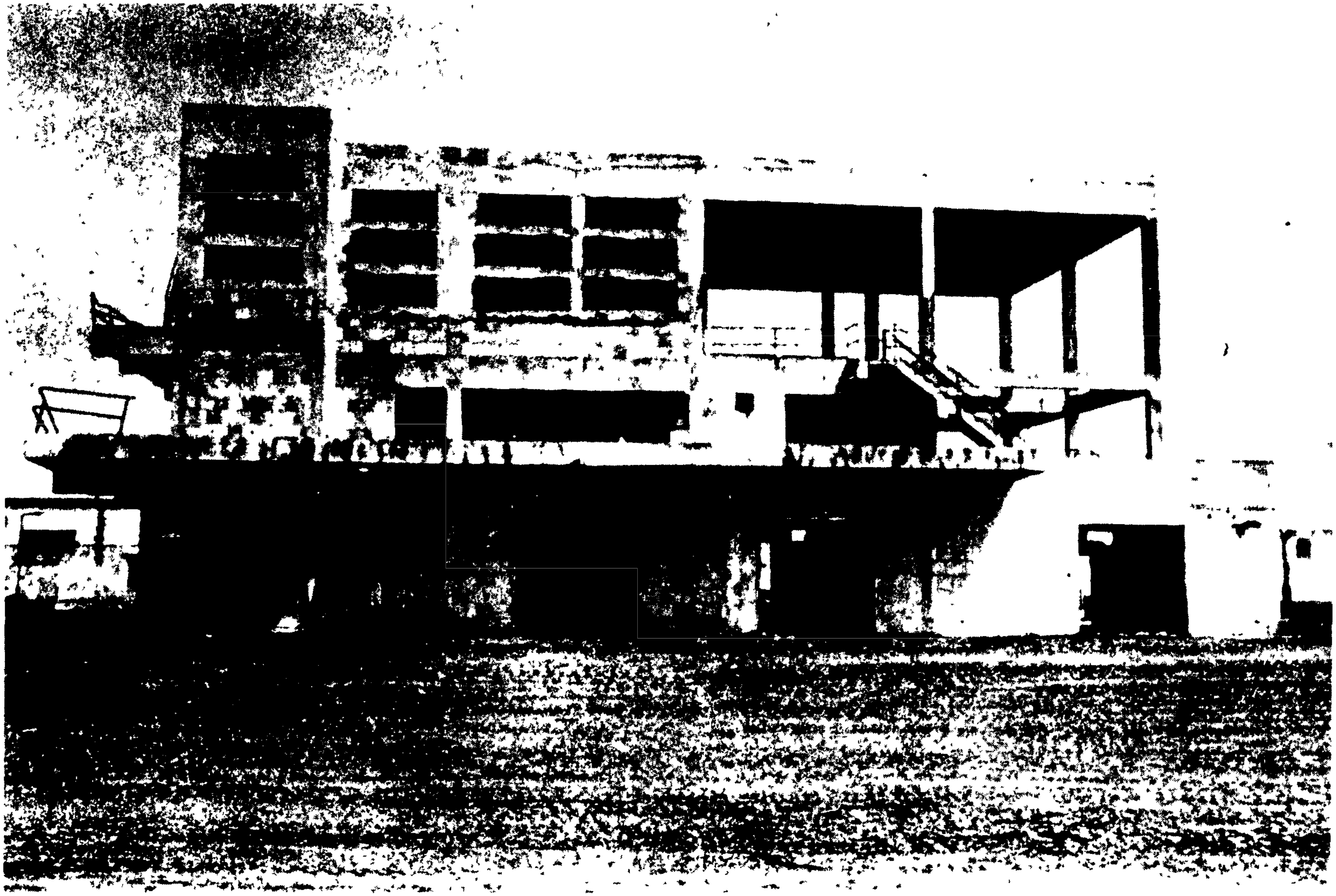


FIGURE II–5 LEWISITE MANUFACTURING BUILDING, JUNE 1977

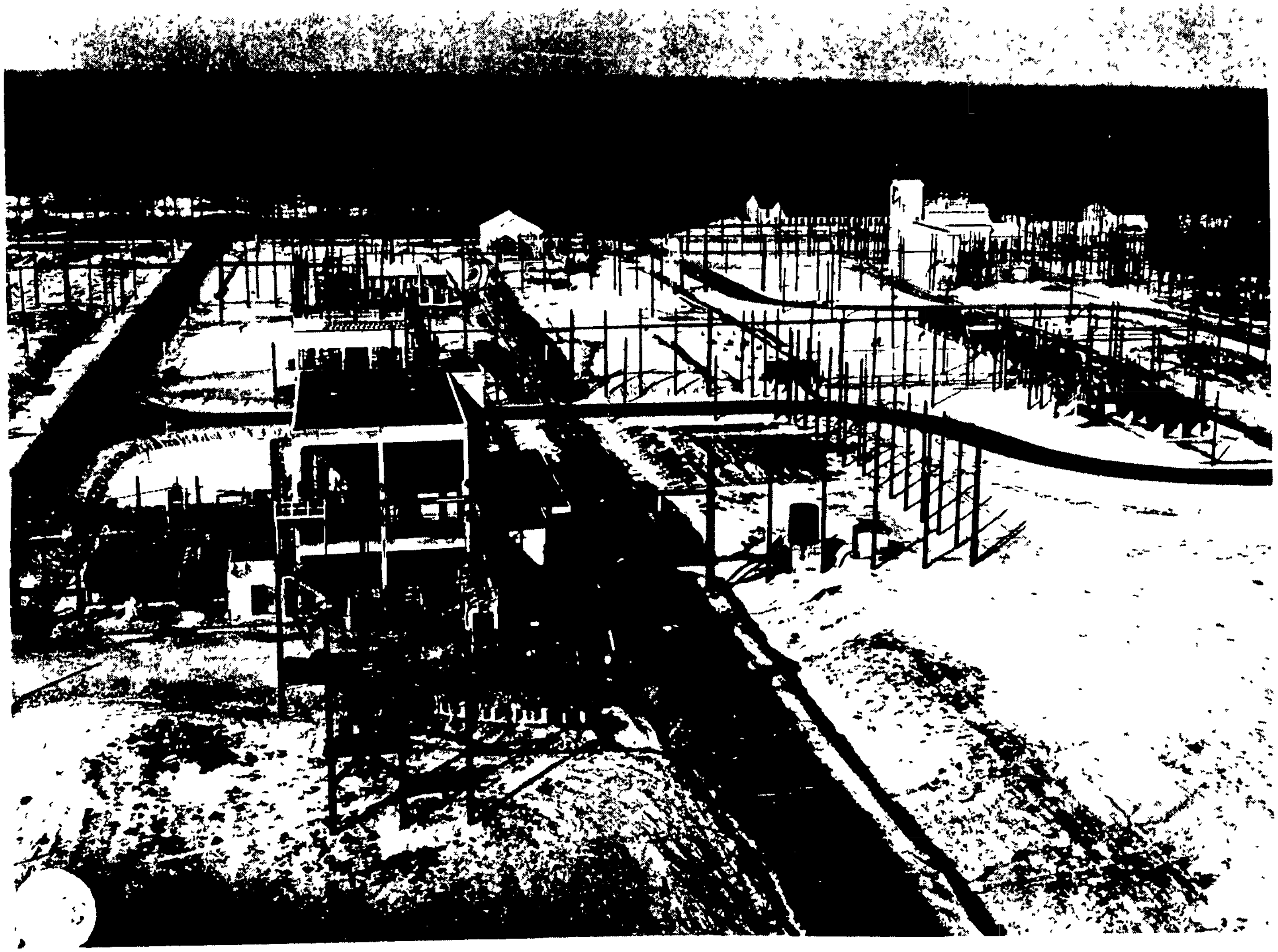


FIGURE II–6 PANORAMIC VIEW OF L AND AT MANUFACTURING BUILDINGS AT PBA, 12/2/43

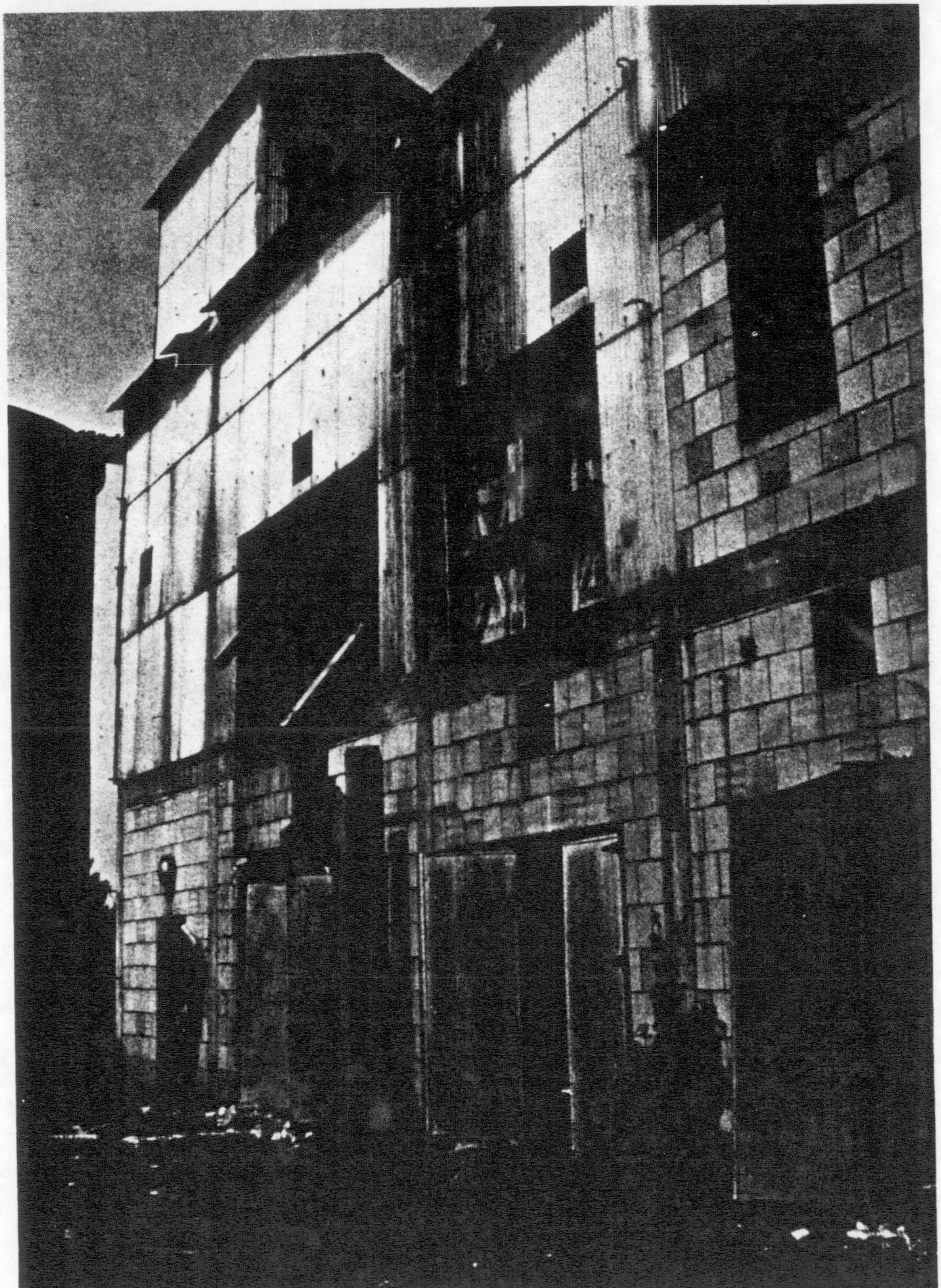


FIGURE II–7 ARSENIC TRICHLORIDE MANUFACTURING BUILDING, JUNE 1977

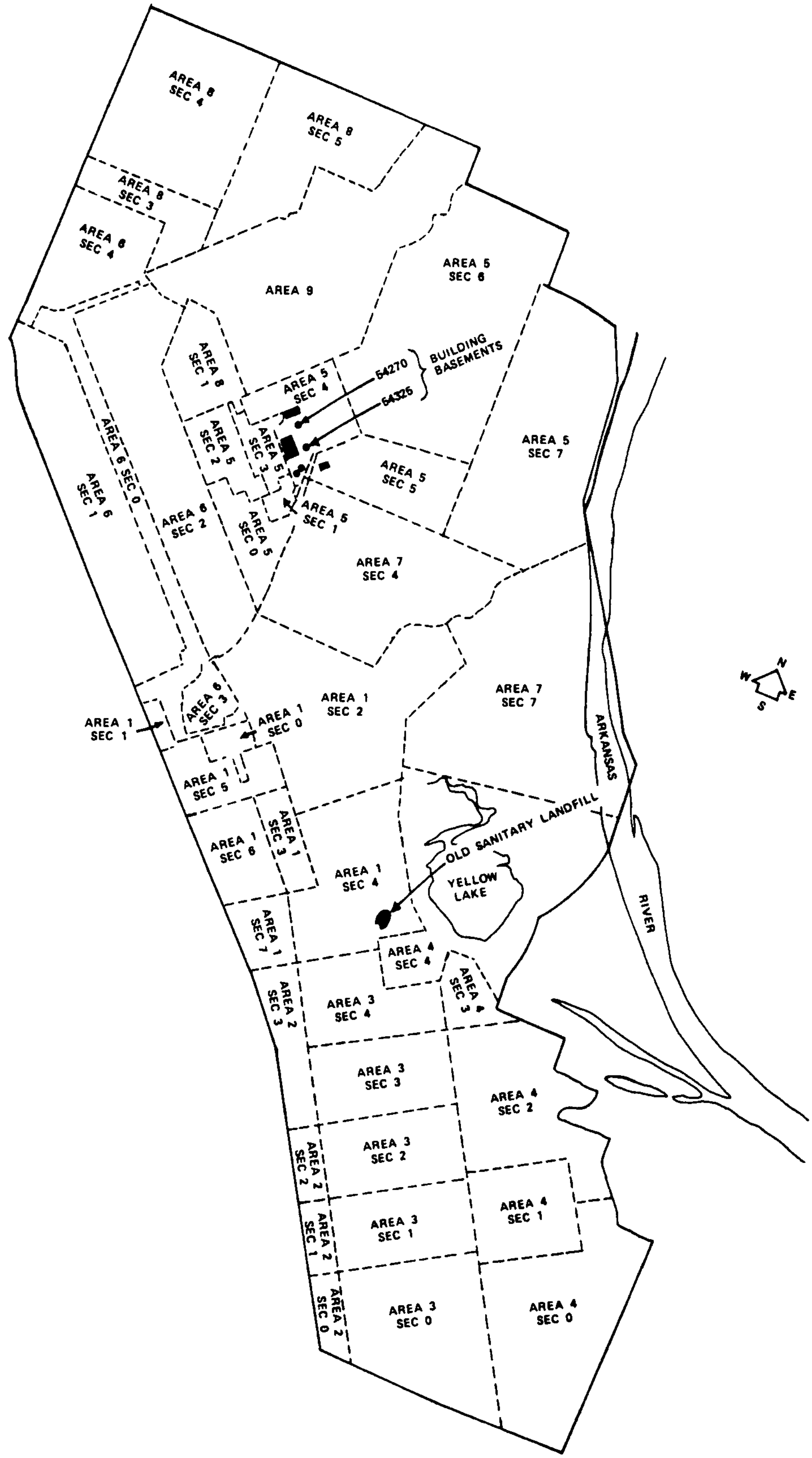


FIGURE II-8. KNOWN AREAS OF DDT CONTAMINATION

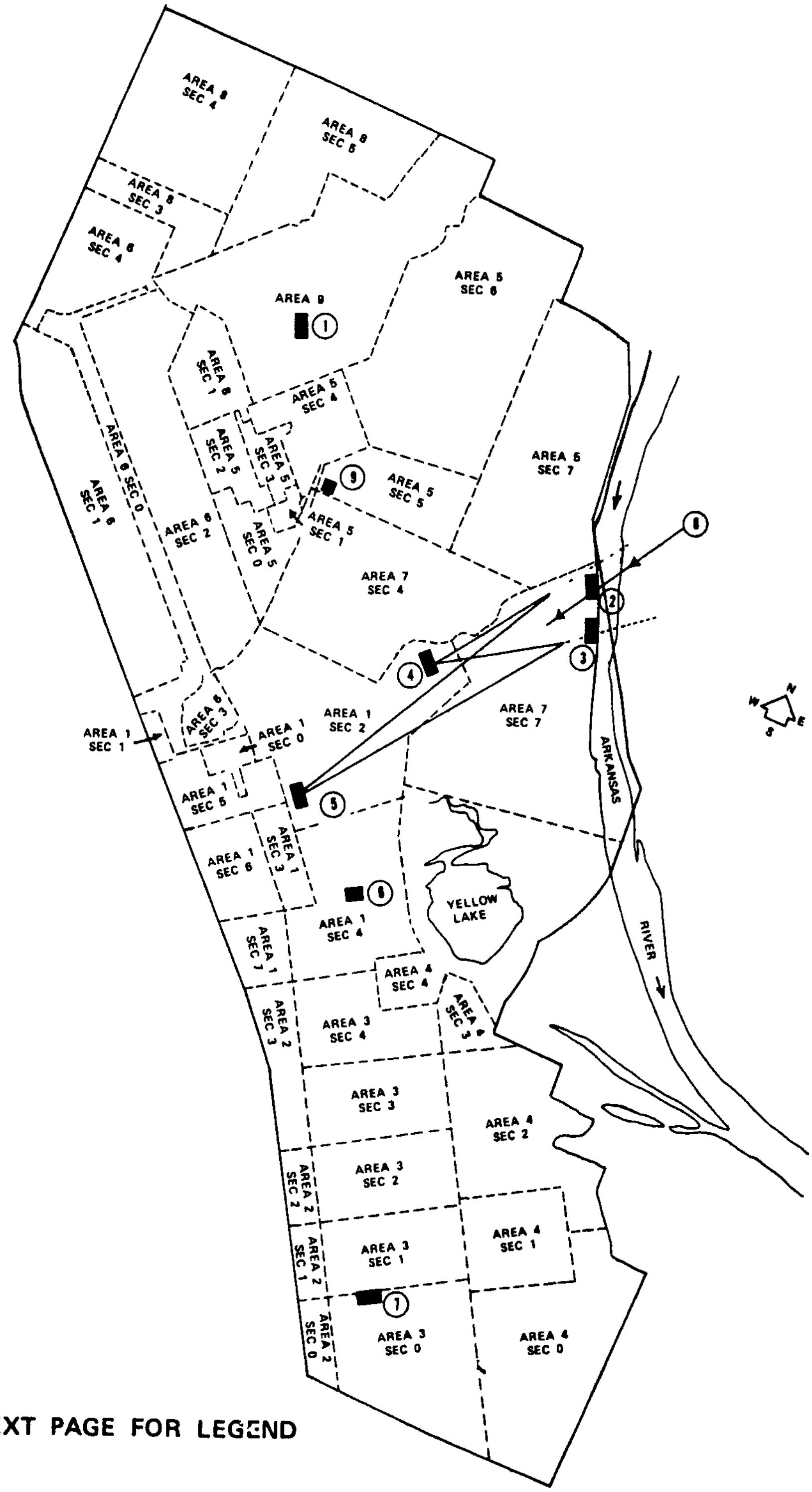


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FIGURE 11-9. AREAS SUSPECTED OF CONTAMINATION

LEGEND

1. DBO BURIAL SITE:– SLUDGE FROM DEMILITARIZED BW AGENTS. LOCATED BETWEEN POLES 9B 27 AND 9B 31 ALONG POWER LINE B, IN USE DURING 1971.

2. BLUFF OVER ARKANSAS RIVER: GENERAL DEBRIS, SUCH AS, WIRE SCREEN, CONCRETE FORMS, ETC., ON SURFACE.

3. OLD BURIAL PITS: LOCATED ALONG ARKANSAS RIVER NORTH OF SUSPECTED CONTAMINATED SITE NUMBER 12. THOUGHT TO CONTAIN JUST ABOUT EVERYTHING.

4. SHORT RANGE GUN EMPLACEMENT: POSSIBLE 4.2 INCH WP AND HE UNEXPLODED ORDNANCE WITHIN THE SURFACE DANGER ZONE, IN USE BETWEEN 1942 THROUGH 1944.

5. LONG RANGE GUN EMPLACEMENT: POSSIBLE 4.2 INCH WP AND HE UNEXPLODED ORDNANCE WITHIN THE SURFACE DANGER ZONE, USED DURING PERIOD OF 1942 THROUGH 1944.

6. OLD BURNING GROUND: USED 1942 THROUGH 1944 FOR NP DISPOSAL.

7. FORMER DEMILITARIZATION SITE: PRIMERS FROM M50 BOMBLET, IN USE FROM 1948 THROUGH 1950.

8. BOMBING FLIGHT PATH BETWEEN ARKANSAS RIVER AND BOMBING MAT: POSSIBLE UNEXPLODED BOMBLETS ALONG FLIGHT PATH.

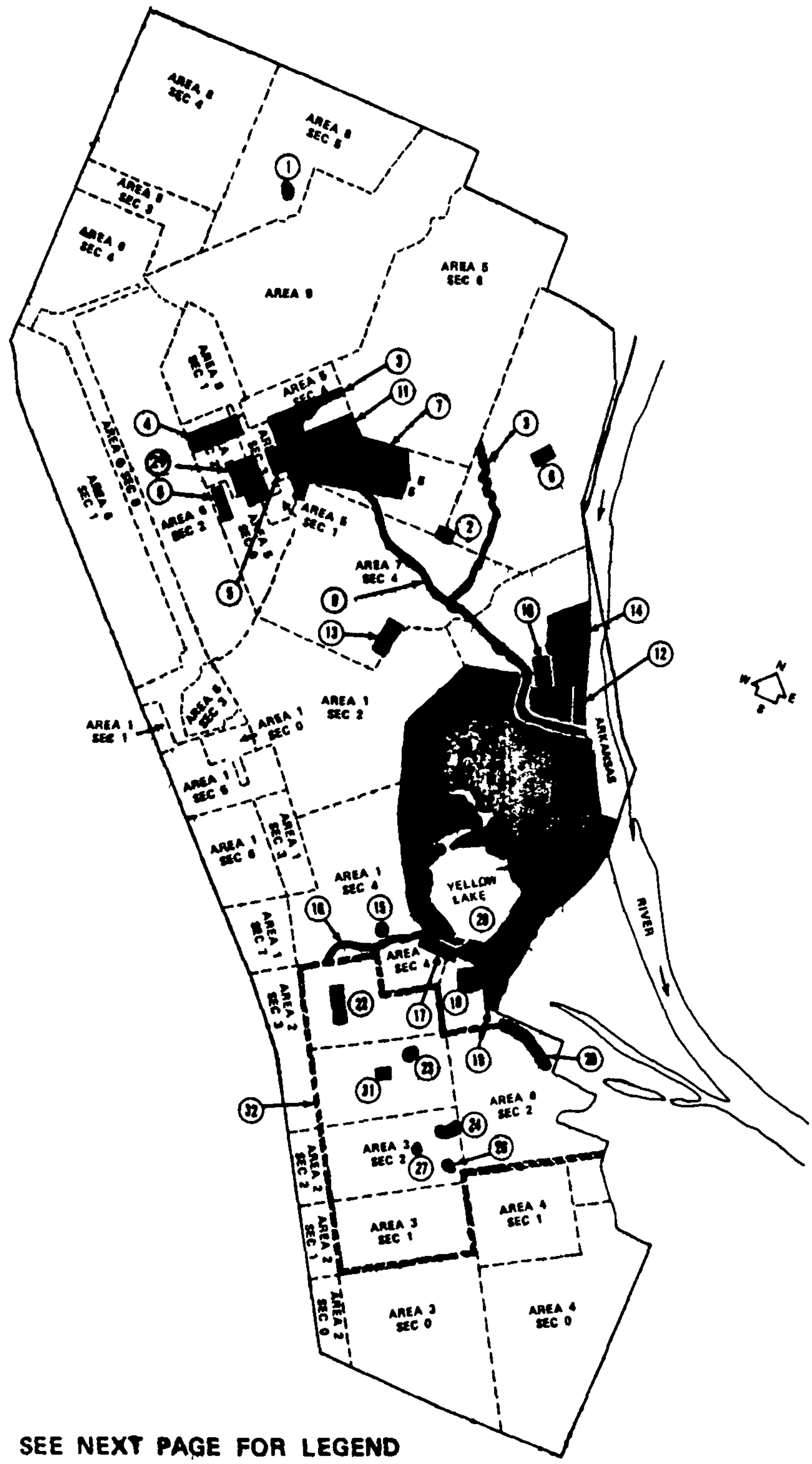

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FIGURE II-10. AREAS OF CONTAMINATION AT PBA

LEGEND

AREAS OF SUSPECTED CONTAMINATION AT PBA

ITEM	CONTAMINANT	PERIOD	LOCATION
1	CONSTRUCTION WASTE	1955/1956	AREA 8, SEC 5. AREA ACROSS FROM BLDG 85–160 AND 85–161.
2	M6, CN, DM	1944/1948	AREA 5, SEC 6 & &. AREA NORTH OF WEBSTER ROAD, WEST OF INTERSECTION WITH DOOLITTLE ROAD. TEST SITE.
3.	ACID, $AsC1_3$ WASTE, DDT	1945/1948	AREA 5, SEC 4. NORTH AND WEST OF BLDG 54–500.
4	MUSTARD, INCENDIARIES	BURNED 1944/ COVERED 1946	AREA 5, SEC. 2. ABANDONED BURNING SITE WEST OF THE INTERSECTION OF 504TH ST. AND AVE. 6242.
5	MUSTARD	BEFORE 1946	BLDG 53–990. BASEMENT AND NETWORK OF TUNNELS LOCATED BENEATH FIRST FLOOR, CURRENTLY FILLED WITH WATER.
6	INDUSTRIAL SOLID WASTE	BEFORE 1969	AREA 5, SEC 0. AREA SOUTHWEST OF ARKIS CHEMICAL MANUFACTURING AREA, 300 FT BY 1,300 FT.
7	MUSTARD, OTHER CONTAMINATION SUSPECTED	BEFORE 1946	AREA 5, SEC 5. BARROW PITS ADJACENT TO SOUTH EDGE OF TOXIC STORAGE YARD AND THE TOXIC STORAGE YARD.
8	FLOATING HC SMOKE POTS	CURRENT USE	AREA 5, SEC 7. POND ON DOOLITTLE ROAD. TEST SITE.
9	MUSTARD	RAIN RUN–OFF	AREA 7, SEC 4. STREAM RUNNING FROM TOXIC STORAGE YARD TO ARKANSAS RIVER.

LEGEND (CONTINUED)

AREAS OF SUSPECTED CONTAMINATION AT PBA

ITEM	CONTAMINANT	PERIOD	LOCATION
10	CS, PYROTECHNICS, MUNITIONS, SMOKES, INCENDIARIES	CURRENT USE	AREA 7, SEC 7. DEPOT'S BURNING AND DEMOLITION AREA.
11	ARSENIC, MUSTARD, LEWISITE, DDT	BEFORE 1956	AREA 5, SEC 4. EAST OF BLDG 54–500, 507TH ST. TO ATKISSON ROAD. 47 BUILDINGS, STRUCTURES, SLABS AND PITS, INCLUDES FOUNDATIONS OF FORMER BUILDINGS 54–270 AND 54–325.
12	LEWISITE, PHOSGENE, MUSTARD FILLED AMMUNITION AND COMPONENTS	BEFORE 1948	AREA 7, SEC 7. ABANDONED BURNING PITS SOUTH–WEST OF THE ARKANSAS RIVER AND EAST AND SOUTHEAST OF BOMBING MAT.
13	PYROTECHNICS	APPROX 1960	AREA 7, SEC 4. ABANDONED BURNING SITE NORTH–WEST OF McCOY ROAD, APPROXIMATELY 1,000 FT NORTH OF INTERSECTION OF WISE AND McCOY.
14	WP TRENCH MORTAR, PYRO–TECHNICS, DUDS (POSSIBLY ALL CONTAMINANTS FOUND AT PBA)	1943/1948	AREA FROM BLDGS 42–410 & 44–301 TO BOMBING MAT. PROOF TEST AREA INCLUDING YELLOW LAKE AND THE AREAS NORTH AND EAST OF YELLOW LAKE.
15	GARBAGE, DDT	1948/1968	AREA 4, SEC 4. SANITARY FILL 600 FT NORTH OF INTERSECTION OF HOADLEY AND McCOY ROADS.
16	WP	CURRENT USE	AREA 4, SEC 4. STREAM RUNNING FROM WP POND TO YELLOW LAKE.
17	PYROTECHNICS, INCENDIARIES, COLORED SMOKES, CS, CS2, CN, DM, HC, AND MUNITION SHELL CASTINGS	CURRENT USE	AREA 4, SEC 4. QSO TEST RANGE, 300 FT BY 1,400 FT, NORTH OF BLDG 44–300.
18	GARBAGE AND INDUSTRIAL WASTE	1968 TO PRESENT TIME	AREA 4, SEC 3. SANITARY FILL NORTH OF McCOY ROAD, EAST OF DILLY FARM.

LEGEND (CONTINUED)

AREAS OF SUSPECTED CONTAMINATION AT PBA

ITEM	CONTAMINANT	PERIOD	LOCATION
19	TRASH	CURRENT USE	AREA 4, SEC 3. FACILITIES BURNING PIT.
20	WP AMMUNITION		AREA 4, SEC 2. BURNING AND DEMOLITION AREA FOR DEPOT, NORTH OF McCOY ROAD.
22	WP, CONSTRUCTION DEBRIS	1944/1970	AREA 3, SEC 4. OLD 15 INCH WP LINE FROM BLDG 34–170 TO THE SOUTHEAST CORNER OF BLDG 34–110.
23	SMOKE GRENADES	CURRENT USE	AREA 3, SEC 3 PRODUCTION TEST AREA.
24	THERMITE WASTE FROM BZ POND	BEFORE 1951	AREA 3, SEC 2. AREA SOUTHWEST OF STOKES ROAD AND 400 FT SOUTH OF THE INTERSECTION OF EVERETT DRIVE.
26	THERMITE, HC, INCENDIARY, COLORED SMOKE	CURRENT USE	AREA 3, SEC 2. AREA AROUND BLDG 32–014.
27	THERMITE WASTE FROM BZ POND	BEFORE 1951	AREA 3, SEC 2. AREA EAST OF BZ POND.
28	PHOSPHATES DISSOLVED IN WATER OF YELLOW LAKE	CURRENT USE	YELLOW LAKE. SLUDGE AND WATER OF YELLOW LAKE.
29	SODIUM CHLORIDE	BEFORE 1969	AREA 5, SEC. AREA BOUNDED BY 502 & 504 STS. AND AVE. 51
31	SMOKE MUNITIONS RESIDUE	CURRENT USE	AREA 3, SEC 3. QC TEST SITE.
32	———	———	AREAS 3 AND 4. TWENTY–TWO DRAINAGE DITCHES.

* NUMBERS 21, 25, AND 30 NOT USED.

TABLE II-4. POTENTIAL POLLUTANTS FROM THE PYROTECHNIC COMPLEX

Acetone	Hexachloroethane
Acid, Hydrochloric	Ink
Acid, Sulfuric	Iron Oxide
Aluminum, Powder	Kerosene
Auramine HCl	Lacquer
Barium Nitrate	Lactose
Benzanthrone	Magnesium Carbonate
Black Powder	Nitrocellulose
BZ Agent	Paint Thinner
Castor Oil	Particulate
Charcoal	Phosphoric Acid
CN Agent	Potassium Chlorate
Cornstarch	Potassium Nitrate
CS Agent	Primer Cord
Decon Solutions (Danc, DS-2, STB, HTH)	Red Lead (Lead Oxide)
Detergents	Silicon
Dextrin	Sodium Bicarbonate
Diatomaceous Earth	Sodium Hydroxide
DM Agent	Sugar
Dye (reds, green, yellow, violet)	Sulfur
Enamel	Titanium
Graphite	Trichloroethylene
Gum, Arabic, 8% in H_2O	White Lead
HC Mix	Zinc
Heptane	Zinc Oxide

Wastes generated in the white phosphorus area include steam condensate, "phossy water" from direct contact with molten phosphorus, and other wastewaters such as floor washing, etc. These waters (with the exception of steam condensate) are high in elemental phosphorus, phosphates, and sodium. White Creek receives wastes from shop and production areas and drains them into Yellow Lake (Figure II-10). Disturbing the waters of this creek brings up fine solids from the creek bed that produce a white smoke upon exposure to air due to the presence of white phosphorus in the solids.

The area surrounding the old chemical manufacturing area is probably the most heavily contaminated area on the Arsenal. The production of mustard, lewisite, sulfur monochloride, chlorine, and arsenic trichloride have resulted in contamination of many buildings and their surrounding properties as a result of spills and early practices of indiscriminate disposal. In addition, Triplett Creek, which drains not only the manufacturing area but also the Toxic Storage Yard, is also contaminated. Lewisite production, for example, provided a sludge which contained arsenic trioxide, mercurous chloride, and organic polymers. Disposal procedures used for these materials are unknown.

Outleasing of facilities during the early 1950's for the production of DDT (building 54-140 was the primary building) resulted in contamination of the entire manufacturing area, the surrounding streams, several dump areas, and an old sanitary landfill. The results of a comprehensive study conducted on the DDT problem by AEHA may be found in Report 99-065-75/76, dated 28 - 31 July 1975, and attached as Appendix L.

During the years of DBO operations (1953 to 1969), waste products routinely produced in the manufacture/handling of BW materials were sterilized by either heat treatment or incineration prior to discharge into the sewer system. The sewer empties into the Eastwood Bayou which drains the northern part of the Arsenal and subsequently discharges into the Arkansas River. After the closure of DBO, materials stored in the igloos were removed and the igloos were decontaminated. During this period the industrial and sanitary sewers were combined. The BW organisms taken from storage were destroyed by heating them at 300°F for 10 minutes. Resulting wastes were sent to a conventional sewage treatment plant for biodegradation. Effluent from the sewage treatment plant was concentrated in a lined evaporation pond. Sludge from the pond was put on the ground along power line B right of way between poles 9B27 and 9B31 and disked into the soil. (See Appendix M.) Other materials/equipment were decontaminated by heating them in a smelter in building 85.

B. <u>Laboratory Facilities</u>

Building 54-500 was utilized during the earlier days of lewisite manufacturing as an analytical laboratory and it was later used as an administrative building for the facilities engineers. Presently the structure is unoccupied and is suspected of being contaminated with mustard, lewisite, arsenic and DDT in the drainage network.

There are three active laboratory buildings at Pine Bluff. Buildings 32-130 and 32-150 perform analytical and physical testing, respectively. They are located in the northeast part of area 3, section 2. The Product Assurance Directorate (PAD) Laboratory is a well equipped facility housed in building 34-111. Work performed in the PAD Laboratory includes: product acceptance, surveillance, control, and special investigative testing. Materials analyzed in the PAD Laboratory are listed in Table II-5. Radiographic non-destructive inspection is performed in the X-ray Laboratory (building 34-111) on munitions ranging in size from small items to 155mm projectiles. White phosphorus and liquid filled munitions; smoke/incendiary grenades, pots, and rockets; along with warheads and projectiles from the LAP lines receive this type inspection. Special agent testing (BZ, mustard, etc.) is also performed in this Laboratory.

Ancillary test facilities include the following: In building 44-125 there is a pendulum device for free-fall testing of M69 and M74 incendiary bombs. Electronic equipment for testing fuzes, grenades, etc., are located in building 44-330. A wind tunnel used to test CS and BZ products disseminated in a solid micropulverized state or in a smoke cloud is located in the Agent Return Test Facility, building 32-535. Building 44-330, located at Dilly Farm near Yellow Lake, is a proof/test facility that provided controlled temperature conditions and fuze testing. Deep freeze, low temperature, and high temperature aging equipment are housed in building 31-750, the First Article Inspection Station. A drop tower, structure 32-690, permits testing of AN-M50 and M126 bombs from heights up to 40 feet.

TABLE II-5. MATERIALS INCLUDED FOR ANALYSIS AT PAD LABORATORY

Acids	Oils
Adhesives and Adhesive Tape	Paint, Lacquers, and Stencil Inks
Alkalies	Pettman's Cement
Aluminum	Pottassium Chlorate
Bleach	Red Lead
BZ	Silicon
Casein	Soaps
Charcoal	Sugar
Chlorates	Sulfur
CS	Thickener
Dyes	Titanium
Glue	Vesicant Detector Crayon
Hexachloroethane	Vesicant Detector Papers
Impregnite	Waterproof Liners
Incendiary and Smoke Mixes	White Phosphorus
Iron Oxide	Yeast
Molasses Residum	Zinc Oxide
Mustard Gases	Others

C. Field Test Ranges/Sites

Eight test areas used in the past for chemical munitions have been located on the Arsenal (see Figure II-11): A pond on Doolittle Road (area 5, section 7) for testing smoke pots; the burning and demolition area southwest of the bombing mat (area 7, section 7) for items manufactured by PBA or stored by the Depot; an alternate site north of the intersection of Wise and McCoy Roads (area 7, section 4) for testing/burning CS when wind conditions preclude use of site area 7, section 7; a QSO test range north of building 44-300 (area 4, section 4) at Dilly Farm on the bluff at Yellow Lake used for any test item except CS; a production test area (area 3, section 3) for smoke grenades; a drop tower (building 32-014, area 3, section 2) for thermate, incendiary, HC and colored smoke munitions; a QC test site (area 3, section 3) for HC and colored smoke; and a concrete mat for air drop testing of bombs and a range for testing M74 rockets and M47 grenades (area 7, section 7).

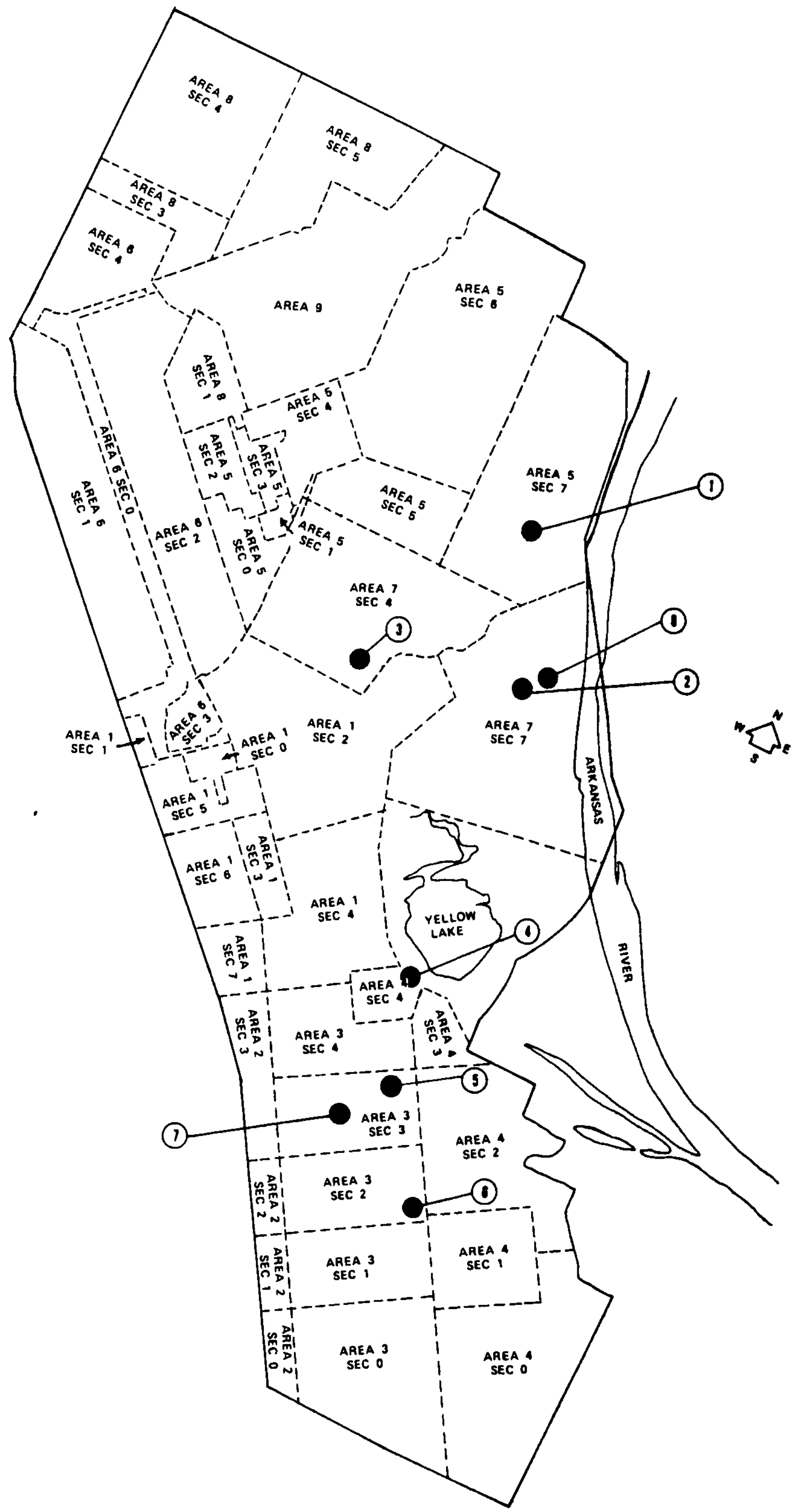


FIGURE II-11. LOCATION OF TEST SITES

It is estimated that 0.2% of all materials produced at PBA were tested. Another indication of the amount of testing that has been done at PBA can be seen at the QC test site at Dilly Farm where the bank surface, measuring approximately 90 feet wide by 20 feet deep, has been extended approximately 20 feet towards Yellow Lake with fill consisting of test materials.

The Arsenal has one rifle range (area 1, section 2) located off of McCoy Road at the end of Turner Road which is used for weapon familiarization only.

D. <u>CBR Burial Sites/Disposal Areas</u>

Historical documentation collected during the Team survey revealed that at least five burial pits, located south of the Toxic Storage Yard, were used extensively for the disposal of mustard filled munitions and containers. Included were items such as 55 gallon drums, ton containers, M2 shells, 4.2 inch shells, and M70 and M47 bombs containing mustard agent. In 1955 PBA opened the pits and demilitarized the containers/munitions, decontaminated the pits with STB, and refilled them with dirt. Historical photographs of the clean-up operations are included as Appendix B. Recent soil tests show that the area south of the Toxic Storage Yard is heavily contaminated with thiodiglycol, a decomposition product of mustard.

The Directorate of Depot Operations has the responsibility for the disposal of contaminated wastes at PBA. It has been estimated that there are approximately 200 pounds per week of munition wastes alone that require disposal. These materials were demilitarized by open-pit burning in one of two major sites. Munition waste is now held for future disposal when the pollution abatement facilities are completed in CY79. The south burning area is used for the disposal of WP, pieces of fuse material, and CS in pyrotechnic mixture. Materials burned in the north open-pit burning area include contaminated construction and laboratory materials, explosives, smoke grenades, incendiaries, etc., but does not include WP.

Burning of explosives in the past led to wide-spread scattering of munition fragments; consequently, screened enclosures (see Figure II-12) were constructed to contain flying debris from exploding munitions. It was reported that German World War II rounds containing mustard agent were involved in one incident. The mustard rounds were recovered, deactivated, and decontaminated before burial.

E. <u>Storage of Toxic/Hazardous Materials</u>

PBA has four areas designated for the storage of chemical and high explosive materials. These areas are identified as the bomb storage magazine area, the Toxic Storage Yard (TSY), and the north and south igloo storage areas.

The bomb storage magazine area is located in area 4, section 1, and consists of 72 structures which are used exclusively as warehouses. The TSY

FIGURE II-12. SCREENED ENCLOSURE FOR DETONATION OF EXPLOSIVES AT PBA is located in area 5, section 5; it has four warehouses in addition to 89 open chemical storage racks. The north igloo area has 65 reinforced concrete igloos; it was formerly a CG Exclusion Area before termination of the installation's biological operations. It is presently designated a Chemical Limited Area for the storage of chemical surety materials. The south igloo area is subdivided into two sections. One section, designated a Controlled Area, has 192 reinforced concrete igloos and it is used primarily for the storage of conventional munitions. The other section, designated a Chemical Limited Area, is used for the storage of surety material and has 8 reinforced concrete igloos.

There are no radiological or biological materials stored at PBA. However, there are munitions, ton containers, identification kits, etc., stored there that contain GB, VX, BZ, and HT/HD agent(s) in addition to standard munitions.

F. Support Activities

1. Water Supply

All water requirements for PBA are fulfilled utilizing the deep well systems described earlier. An AEHA Water Quality Engineering Survey number 24-002-73 points out that slurry from settled and filtered backwash solids from the chemical area water treatment system was being discharged to natural surface drainage. A subsequent Army construction (MCA) funded project for the modification of solids disposal, incorporating the use of sludge lagoons to contain the slurry, has since been completed. See Appendix K.

2. Waste Disposal

Waste from PBA is in two categories, solid and liquid. Solid waste disposal will be discussed under Sanitary Landfill. Liquid waste disposal includes both industrial and sanitary sewage.

There are two separate collection systems at PBA -- sanitary and industrial. There are also two sewage treatment plants -- the incendiary bomb filling (IBF) area sewage treatment plant and the area 5 sewage treatment plant. The collection systems and locations of these plants are shown in Figure II-13.

The maximum capacity for the IBF plant is 2,000,000 gallons per day. The average flow for a typical period (January to July 1972) was 75,000 gallons per day. This plant receives sanitary sewage from the administrative area, depot operations area, salvage yard, housing area, white phosphorus area, and pyrotechnic area. Effluent from the primary treatment

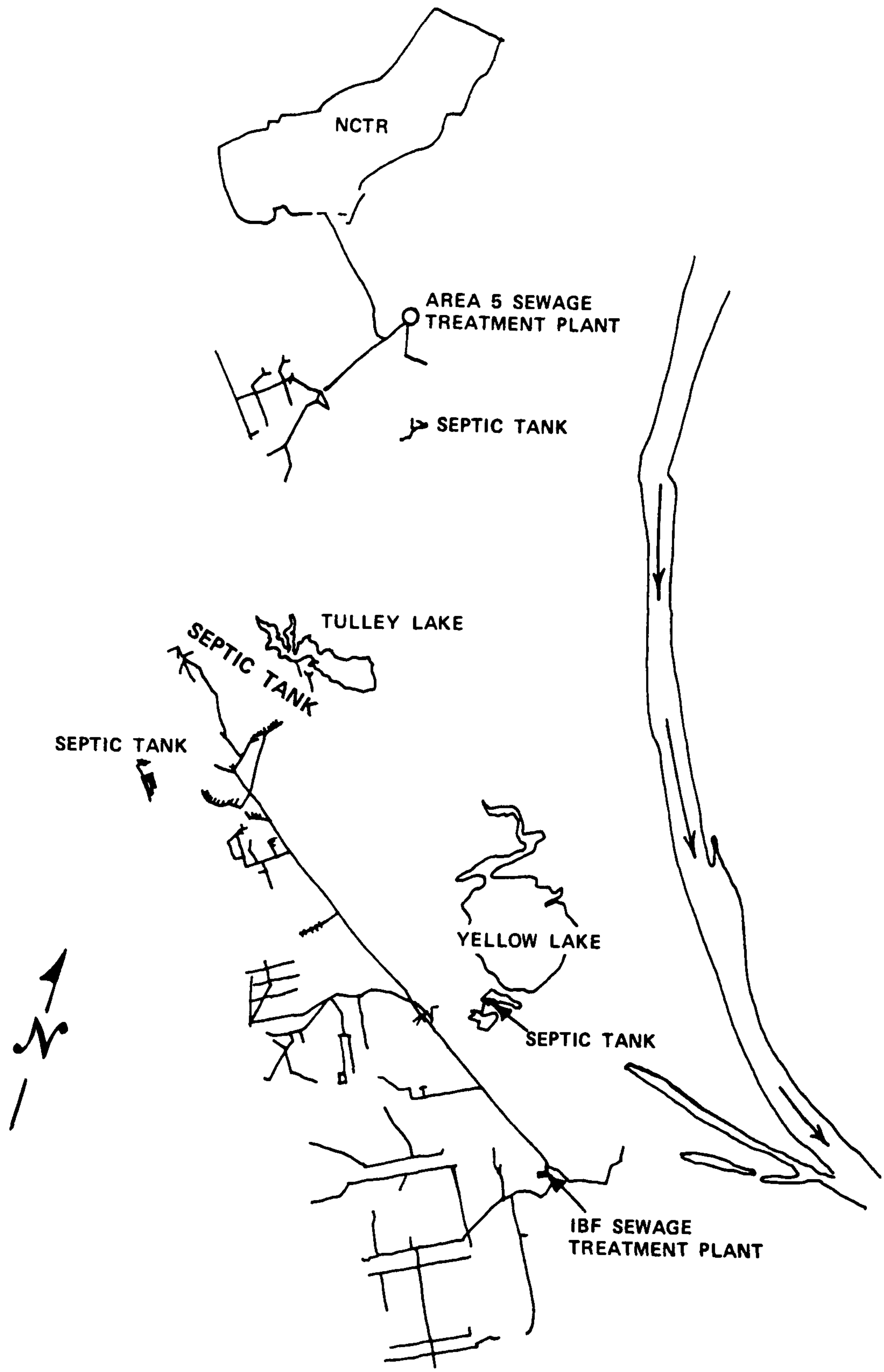


FIGURE II-13. SANITARY SEWER AND COLLECTION SYSTEM PINE BLUFF ARSENAL

is then given a secondary treatment by pumping it to an oxidation pond. Effluent from the pond is chlorinated and discharged into Production Area Creek.

Area 5 (chemical area) sewage treatment plant has a capacity of 1,000,000 gallons per day. Its average flow in 1972 was 45,000 gallons per day. The plant receives sanitary and industrial waste from the NCTR and sanitary waste from area 5. The NCTR sanitary wastes are conveyed directly to the plant. The NCTR industrial wastes are conveyed separately to an equalization pond and, when elevated pH is measured, sulfuric acid is added to the waste just before it enters the pond. The pond effluent enters the NCTR sanitary sewer approximately one-half mile from the sewage treatment plant. Area 5 sanitary waste is conveyed directly to the treatment plant. Effluent from the primary treatment is given a secondary treatment consisting of an Infilco filter and a 20-acre oxidation pond. The effluent from the oxidation pond is then chlorinated before being discharged into Triplett Creek. See Appendix N.

In addition to these two treatment plants five septic tanks are used in remote areas to provide treatment for domestic wastes.

There are three types of industrial wastes at PBA that receive no treatment. These are pyrotechnic area wastes, white phosphorus wastes, and contaminated area runoff. Currently wastewaters associated with the pyrotechnic production activities are discharged directly to surface streams. Wastes from the white phosphorus production area flow directly to a series of settling basins and then into White Phosphorus Creek. All storm runoff waters at PBA flow into open ditches. These ditches drain into the Arsenal streams and eventually reach the Arkansas River. Runoff occurs from previously identified contaminated areas that have been used for disposal of chemical agents, pesticides, trash, white phosphorus, and other wastes. As long as these areas exist there is a possibility that runoff from the areas may contain pollutants. See Appendix K. Industrial Waste Treatment Facilities presently under construction are scheduled for completion during CY79.

G. Land Use Factors

1. Pesticide/Fertilizer

A pesticide program of sorts has been in existence since the activation of the Arsenal. A formal preventive program was initiated in March 1970. A summary of this program is contained in Table II-6.

An herbicide program began in 1960 with the application of polyborochlorate on railroad right of ways. In 1966, Urex II Monuron was substituted for polyborochlorate. Between 1969 and 1971, road shoulders were treated with the herbicide polyborochlorate. In 1962, 1964, and 1972 the application of two pounds per acre of 2,4,5-T and 2,4-D in a 50/50 ratio was used in the igloo area. The 2,4,5-T was used continuously from 1962 to 1971 in selected areas.

Between 1969 and 1972 golf course fairways and administrative area grounds were treated with monosodium methyl arsenate. Since 1968, vegetation around fire hydrants, culvert headwalls, and steam lines near the ground have been treated with a solution of monoborochlorate. In 1963, a program to kill diseased and undesirable species of trees was initiated; this consisted of a 2,4-D injection directly into the tree.

After 1972, the herbicide program, except for the railroad right of ways, was included in the Arsenal vegetation control contract. The herbicides used in this program are included in Table II-6. Since 1971, the application of herbicide on railroad right of ways has been contracted to firms specializing in this type of work. No Standinq Operating Procedure for herbicide and pesticide application exists.

Fertilizer is used annually on all improved grounds. A normal application consists of 20-10-10 (20 pounds of nitrogen, 10 pounds of phosphonic acid, 10 pounds of potash) at a rate of 300 pounds per acre per year. New landscape plantings are fertilized with a 10-20-10 fertilizer.

2. Sanitary Landfills

Solid waste at PBA is separated into salvable, non-salvable, and contaminated waste. Salvable waste is hauled to the Salvage Yard for disposition. Non-salvable waste is hauled to a landfill site by a contractor. Contaminated material is collected and disposed of by the Depot Operations Group. See Appendix O.

PBA generates solid waste at an estimated rate of 3,200 cubic yards per month (uncompacted). The present sanitary landfill is located on the Arkansas River terrace along the east-central border of the Arsenal south of Yellow Lake. The 6.5 acre site, of which .75 acres have been filled, employs a trench method of operation. It is being filled at an average rate of .27 acres per year and has a life expectancy of 20 years. Waste delivered to the site is continually spread and compacted. After being compacted, six inches of cover material is placed over the refuse daily.

Several old pit areas were identified on PBA. These are located in Figure II-14. No known contaminants were placed in the pits which contain old lumber and construction debris. The pits located east and west of the firing pads were used for burning powder and munition wastes. See Appendix P.

TABLE II-6. SUMMARY OF HERBICIDE AND PESTICIDE APPLICATIONS AT PBA

Herbicide/Pesticide*	Used for Control of	Where Used
Herbicides		
Monosodium Methylarsonate	Dallisgrass	Golf course and administrative lawn
Bromacil	Conifer & all other vegetation	Igloo area 5, bomb storage magazines, electrical substations, TSY, fences, road shoulders, etc.
2,4-D; 2,4,5-T mixture	Broadleaf vegetation	Igloo areas
Pesticides		
Chlordane, 2% spray	Termites and ticks	Admin & housing area lawns & termite infested bldgs
Chlordane, 5% dust	Ants	Ration storage areas
Diazinon, 1/2% spray	Roaches	Food service and storage areas
Diazinon, 2% dust	Roaches	Military areas only
Duraban, 1/2% spray	Roaches	Food service areas
Malathion, 5% spray	Mosquitoes	Mosquitoes production area
Sevin Dust, 1% dust	Mosquitoes	Mosquitoes production area
Warfarin, 1/4% in grain	Rats	All food storage areas and food service facilities
Baygon, 1% dust	Roaches	All food storage areas and food service facilities
Pyrethrum aerosol, .6% Pyrethrum Insecticide, .04% Pyrethrum Ryonia Pyrethrum BP 300	Flies and roaches	All food storage areas and food service facilities
Roost-No-More	Birds	Production areas

*The use of trade names in this report does not constitute an official endorsement or approval of such commercial products. This report may not be cited for purposes of advertisement.

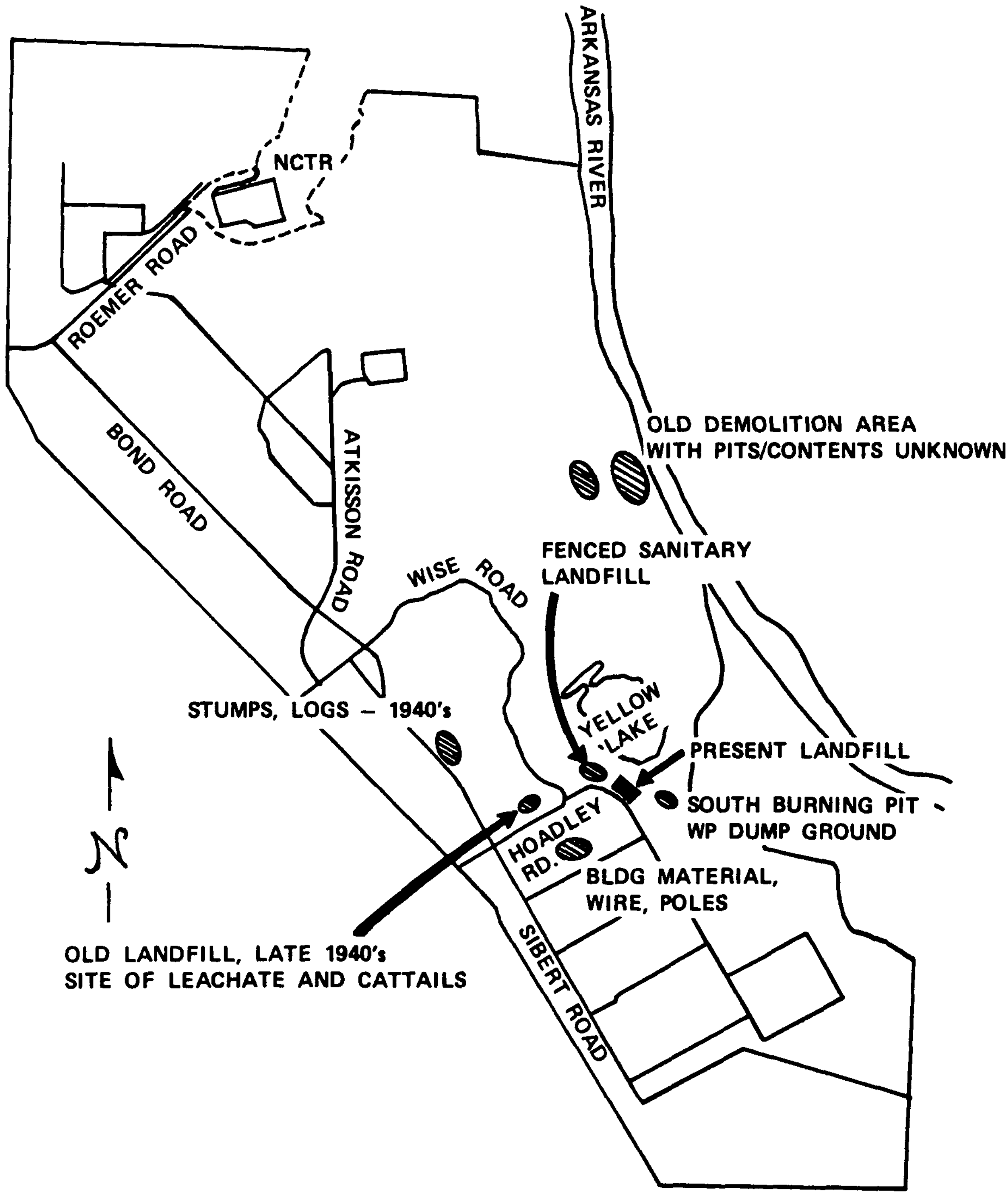


FIGURE II-14. LANDFILL SITES

H. Geological Migration Potential Time/Distance Relationships

Little data is available on the percolation of water from the surface to the shallow water table or groundwater. Average permeability values derived by the US Department of Agriculture are low, implying that only small amounts of rainfall percolate through the upper soil to the groundwater. Minimum permeability values indicated by USDA for the upper six feet of soil in the old ARKLA Plant area vary from 0.2 to 0.6 inches per hour.

An AEHA Water Quality Geohydrologic Consultation, number 24-004-74, mentions a mean velocity of 25 feet per year for horizontal movement in the shallow water table. This velocity, referred to also under Subsurface Water Quality, was based on a single estimate.

A hydrogeologic sampling program currently being conducted at PBA by the Waterways Experiment Station should yield more information on this subject. See Appendix Q.

I. Environmental Indications

1. Land Indicators

Several closed disposal sites do not have an adequate thickness of final cover. In some cases water has infiltrated and exposed refuse, producing numerous leachate springs around these sites. One of the leachate springs is located at the foot of an abandoned landfill area northeast of the white phosphorus settling basins. There are uncrushed barrels and glass jars lying exposed on the surface. The spring is surrounded by a growth of cattails. A reddish-colored leachate has filtered downslope from the spring. No vegetation grows where the red leachate has flowed. See Appendix K.

2. Waterways Indicators

Results of aquatic surveys at PBA have shown that fauna lists for parts of Triplett Creek are restricted to a few species which are tolerant of the identified pollutants (DDT, arsenic, lead, and thiodiglycol). Triplett Creek receives drainage from old chemical sites, toxic waste burial sites, and an old industrial landfill.

An Edgewood Arsenal Technical Report, number EO-TR-76077, "Effects of Elemental Phosphorus on the Biota of Yellow Lake," indicates that elemental phosphorus concentrations could be used to predict species diversity. This diversity was highly correlated with the abundance of a macroinvertebrate (*Limnodrilus hoffmeisteri*). This relationship could be further distinguished as elemental phosphorus concentrations which are toxic, inhibitory, or stimulating to certain species. See Appendixes R and S.

III. FINDINGS

A. Pine Bluff Arsenal is contaminated with hazardous wastes resulting from various operations conducted at the Arsenal from 1942 to the present both by government agencies and by industrial concerns that leased portions of the facility. Potential contaminants identified from the search of records are DDT, arsenic, white phosphorus, barium, zinc, mustard, BZ, riot control agents, pyrotechnic materials, and industrial wastes with their associated breakdown products.

B. Sterilized biological waste was disced into the soil in a field on the property deeded to the National Center for Toxicological Research (NCTR). The buildings presently used by NCTR were formerly the facilities of the Directorate of Biological Operations (DBO) at PBA.

C. Many test areas at PBA may contain unexploded ordnance (UXO). The UXO potentially consists of high explosive rounds, mustard rounds, pyrotechnic munitions (WP, HC, smoke, colored signals), and riot control devices (CS and CN).

D. Radiological materials were not developed, manufactured, stored, tested, or disposed of at the installation.

E. Lethal chemical agents (mustard and lewisite) were manufactured at PBA and mustard agent is presently stored at the Toxic Storage Yard (TSY). Other items in storage at the TSY include War Gas Identification Sets, riot control agents, decontaminants and FS. GB and VX are stored in igloos in the ammunition storage area. BZ is stored in three igloos in the ammunition storage area.

F. Groundwater and the subsurface soil is contaminated in many areas of the installation. Thirty-two sites within the boundary were evaluated by sampling and analyzing for DDT, sodium, barium, arsenic, mercury, lead, zinc, mustard, lewisite, CS, CN, DM, dyes, hexachloroethane, and white phosphorus. Twenty-nine of the sites had at least two or more contaminants at concentrations in excess of critical threshold values established by a team of scientists at the Chemical Systems Laboratory.

IV. CONCLUSION

Current known areas of contamination were substantiated and additional suspected areas were located and documented. PBA personnel were advised of the suspected areas during the Team's exit briefing.

V. RECOMMENDATION

The preliminary surveys presently being conducted at PBA should continue because there is a strong potential of contaminant migration.

APPENDIX A

KEY PERSONNEL INTERVIEWED

APPENDIX B

PHOTOGRAPHS

A STACK OF 4.2 SHELLS THAT HAD BEEN REMOVED FROM FIRST MUSTARD PIT. (28 APRIL 55)

EMPTY ONE TON CONTAINER, "D" TYPE, THAT WAS REMOVED FROM SECOND PIT. (MUSTARD PIT AREA) (3 MAY 55)

THIRD PIT BEING OPENED IN MUSTARD PIT AREA. (1 JUNE 55)

A SIDE VIEW OF MUSTARD PIT AREA (FOURTH PIT) SHOWING A PORTION OF M47 H FILLED BOMBS AND CONTAMINATED WOOD. (24 JUNE 55)

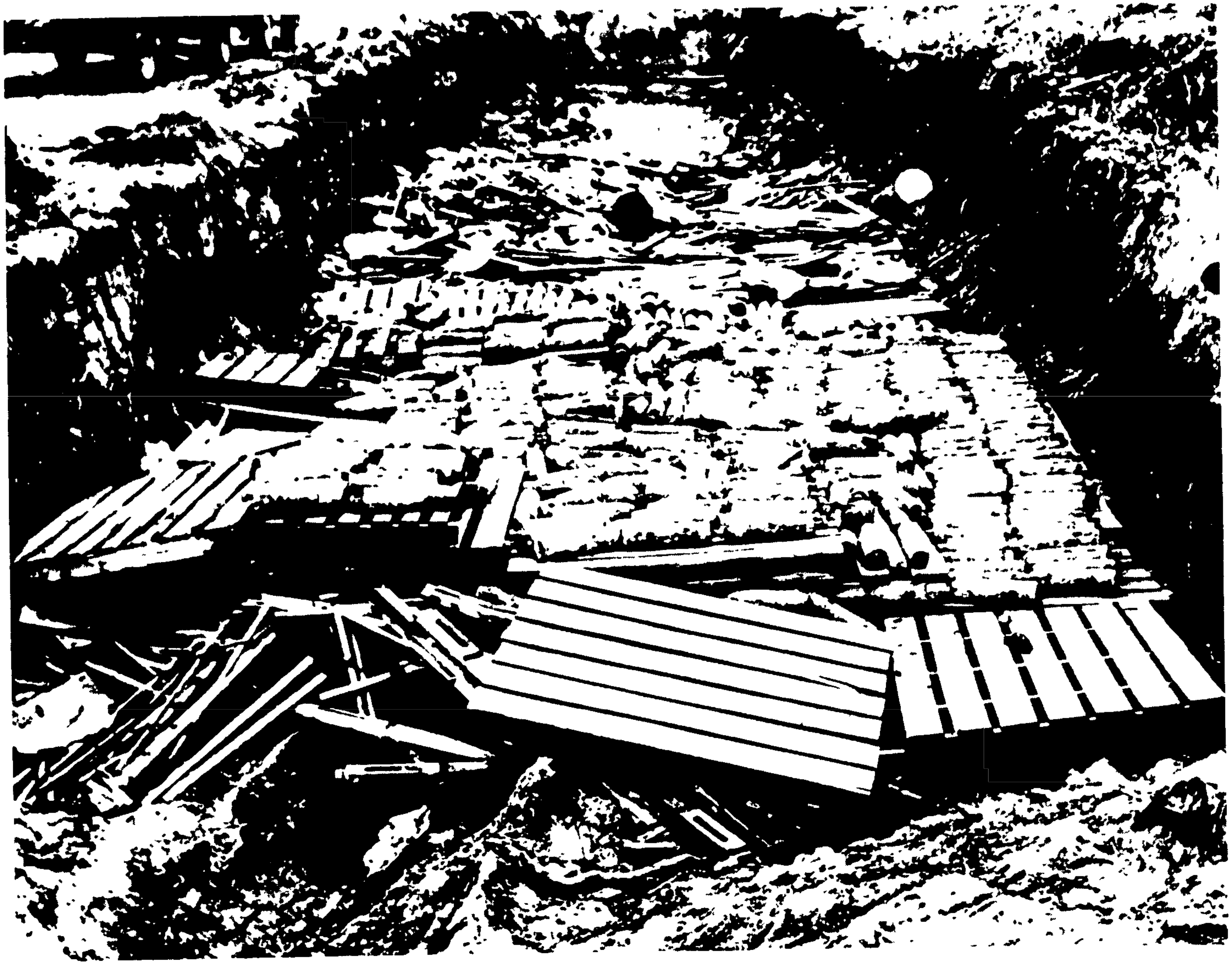
A VIEW OF THE ENTRANCE OF THE FIFTH MUSTARD PIT SHOWING BOXES OF DM M2 CANDLES. (12 JULY 55)

VIEW OF END OF PITS LOOKING INTO BORROW PIT. WATER FILLED PIT CONTAMINATED WITH ? (10 MAY 54)

VIEW OF SCRAP AND BOMB, M47, H CONTAMINATED STORED INSIDE TOXIC GAS YARD. (10 MAY 54)

VIEW OF SCRAP AND BOMB, M47, H CONTAMINATED STORED IN TOXIC GAS YARD. (10 MAY 54)

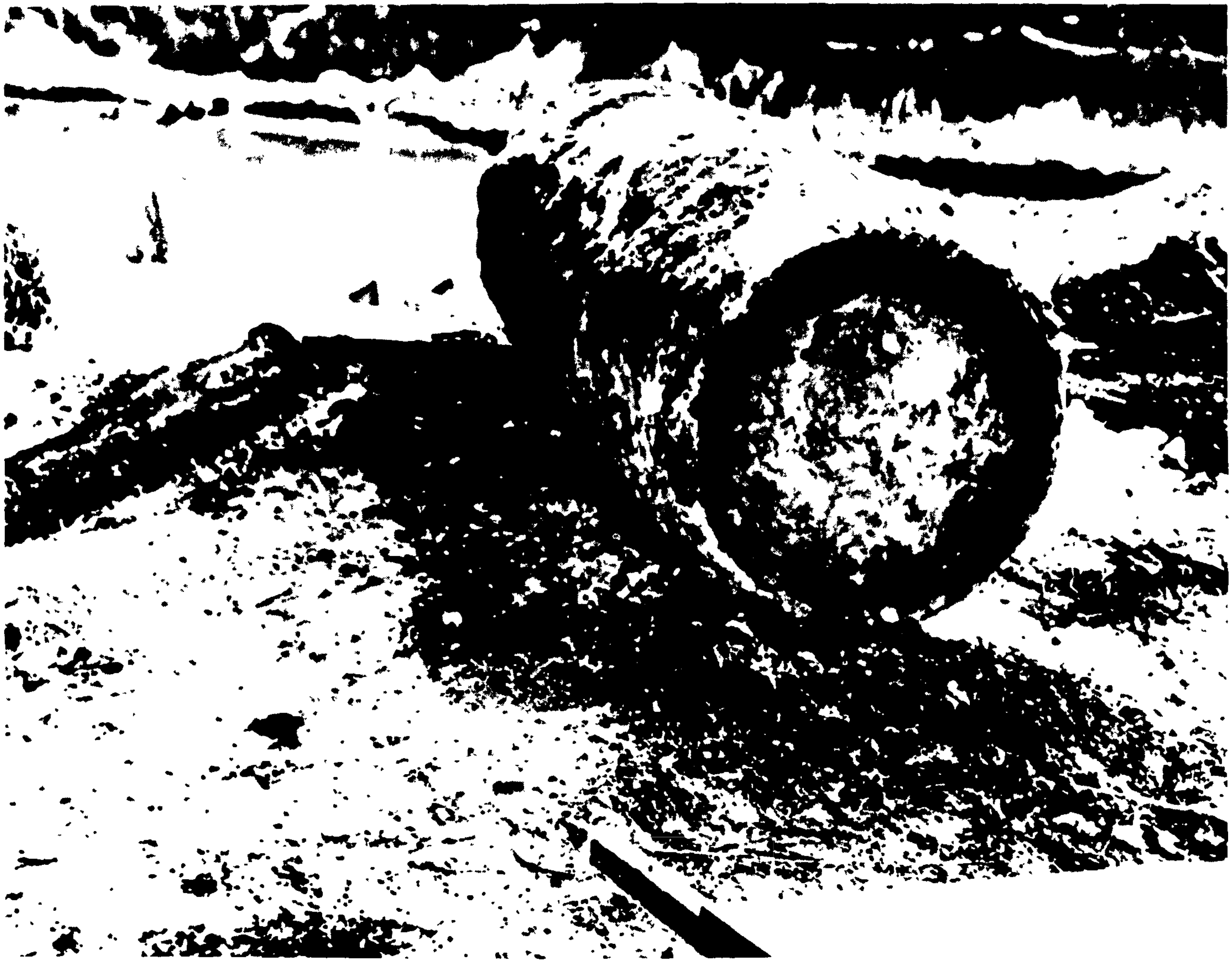
OVERALL VIEW OF BURIED MUSTARD FILLED MUNITIONS, FACING SOUTHWEST. (10 MAY 54)



A PIT THAT HAS HAD INCENDIARY MATERIAL PLACED ON BOTTOM, THE 4 2 SHELLS ON TOP OF MATERIAL IN BURNING PIT AREA. (20 APRIL 55)

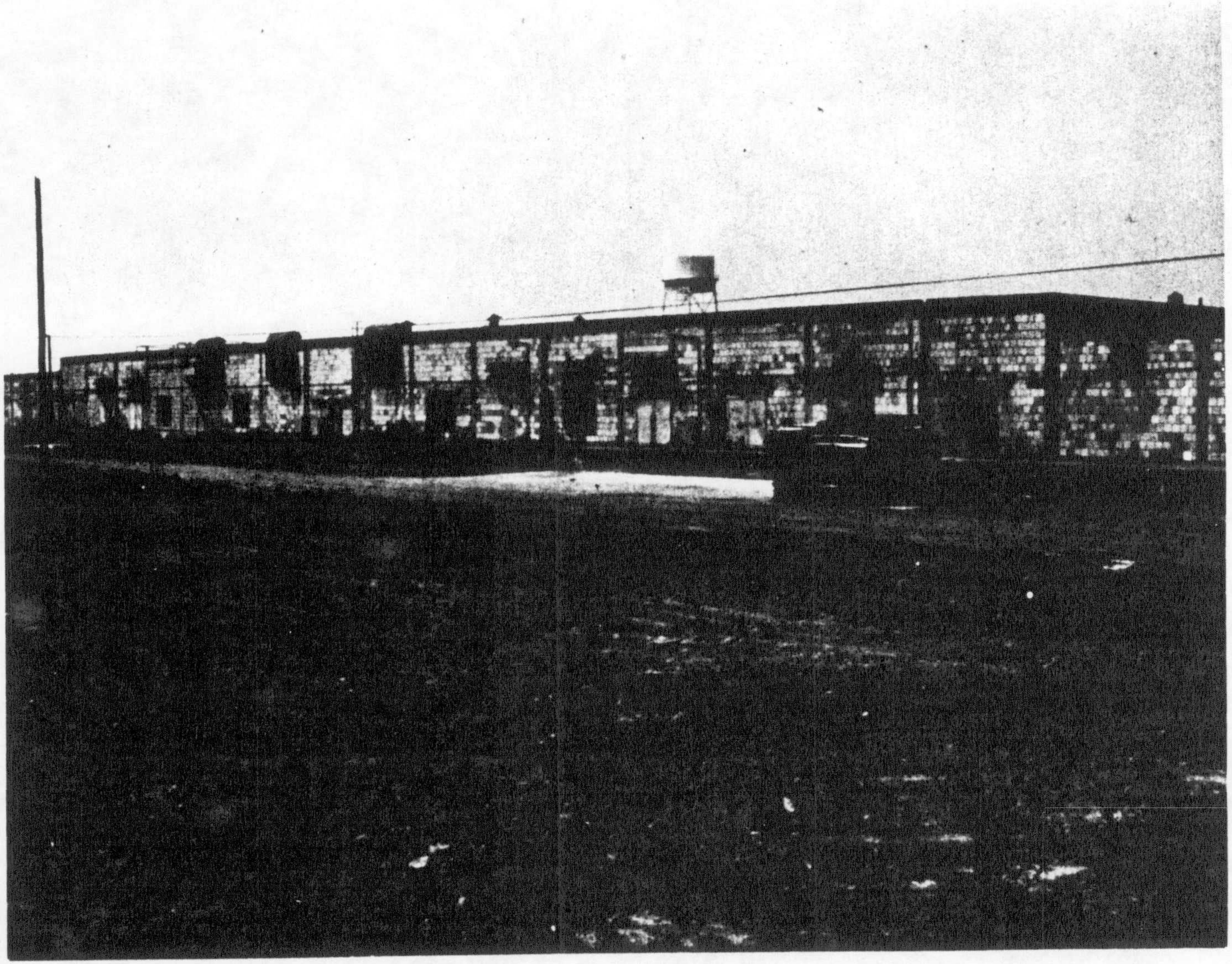
4.2 SHELLS, M70 BOMBS, M47 BOMBS AND OTHER SCRAP DUG FROM MUSTARD PIT. (28 APRIL 55)

LEAKING M70 LEWISITE FILLED BOMBS. (28 APRIL 55)



END VIEW OF TON CONTAINER, "D" TYPE. ONE OF THE ENDS (END SHOWING) IS BULGED DUE TO EXTREME PRESSURE AT ONE TIME. (3 MAY 55)

M70 BOMB BODIES AFTER BEING BURNT IN PITS. (23 JUNE 55)



MUSTARD FILLING BUILDING, PBA, JUNE 1977

APPENDIX C

STANDING OPERATING PROCEDURE NUMBER 74-15

OPERATION OF SOUTH AREA WATER TREATMENT PLANT

PINE BLUFF ARSENAL

A copy of this report can be obtained from:

Department of the Army
Headquarters, Pine Bluff Arsenal
Pine Bluff, Arkansas 71601

APPENDIX D

BORING LOGS

PINE BLUFF ARSENAL

BORING LOGS
WATER QUALITY MONITORING WELLS
PINE BLUFF ARSENAL

Test Numbers 1 and 2

NOTE: Wells 1 and 2 were drilled to 135 and 100 feet respectively without evidence of water. They were abandoned as dry holes.

Test Number 3, 9 May 1967

Elev - Inches From	To	Description
0	27	Fill and silty clay
27	46	White clay
47	79	Blue clay
79	84	Brown clay
84	91	Fine sandy clay
91	178	Clay
178	200	Sandy clay
200	216	Clay
216	217	Rock
217	303	Clay
303	304	Rock
304	321	Clay
321	322	Rock
322	336	Shale
336	337	Rock
337	425	Shale
425	447	Sandy shale
447	457	Shale
457	464	Sandy shale
464	570	Shale
570	640	Fine sandy shale
640	685	Fine sand
685		Break in formation

Test Number 4, 24 May 1967

Elev - Inches From	To	Description
0	23	White sandy clay
23	43	Red sandy clay
43	51	Fine silty sand
51	60	Fine sand
60	68	Coarse sand
68	73	Fine sand
73	81	Coarse sand

Test Number 5, 7 April 1967

Elev - Inches From	To	Description
0	13	Soil and clay
13	23	Fine sand
23	55	Sandy clay
55	63	Fine sand
63	80	Coarse sand
80		Blue clay

Test Number 6, 6 April 1967

Elev - Inches From	To	Description
0	13	Fill and clay
13	20	Fine sand
20	39	Medium sand
39	51	Muddy sand and clay
51	62	Fine sand
62	76	Medium sand
76		Blue clay

Test Number 7, 10 April 1967

Elev - Inches From	To	Description
0	16	Soil and clay
16	32	Fine sandy clay
32	65	Fine sand
65	87	Coarse sand

Test Number 8, 11 April 1967

Elev - Inches From	To	Description
0	37	Soil and sandy clay
37	42	Fine sand
42	68	Coarse sand

Test Number 9, 17 April 1967

Elev - Inches From	To	Description
0	14	Soil and clay
14	22	White sand
22	38	Red sandy clay
38	51	Medium sand
51	62	Coarse sand

Test Number 10, 18 April 1967

Elev - Inches From	To	Description
0	33	Sandy clay
33	48	Medium sand
48	64	Coarse sand

Test Number 11, 18 April 1967

Elev - Inches From	To	Description
0	10	Clay
10	18	White sand
18	31	Sandy clay
31	48	Fine sand
48	64	Coarse sand

Test Number 12, 19 April 1967

Elev - Inches From	To	Description
0	18	Clay
18	21	White sandy clay
21	35	Clay
35	51	Fine sand
51	66	Coarse sand

Test Number 13, 20 April 1967

Elev - Inches From	To	Description
0	59	Clay
59	76	Coarse sand

Test Number 14, 20 April 1967

Elev - Inches From	To	Description
0	10	Clay
10	13	Red sand
13	33	Clay
33	55	Red sand
55	70	Coarse sand

Test Number 15, 21 April 1967

Elev - Inches From	To	Description
0	14	Clay
14	18	White sand
18	33	Sandy clay
33	51	Red sand
51	71	Coarse sand

Test Number 16, 24 April 1967

Elev - Inches From	To	Description
0	7	Clay
7	17	Sandy clay
17	23	Fine sand
23	35	Sandy clay
35	55	Fine sand
55	72	Coarse sand

Test Number 17, 28 April 1967

Elev - Inches From	To	Description
0	42	Clay
42	60	Fine sand
60	77	Coarse sand

Deep Well Number 2

Elev - Feet From	To	Description
0	10	Hard pan
10	30	Sand
30	50	Clay
50	94	Coarse sand
94	100	Clay
100	175	Sandy shale
175	205	Tough shale
205	225	Sandy shale
225	248	Tough shale
248	258	Sandy shale
258	285	Fine sand, streaks of shale
285	286	Rock
286	292	Sandy shale
292	301	Shale
301	316	Sandy shale
316	348	Tough shale
348	352	Hard spot
352	362	Sandy shale
362	366	Tough shale
366	367	Rock
367	370	Tough shale
370	372	Rock
372	382	Shale and boulders
382	383	Rock
383	390	Shale
390	440	Tough shale
440	479	Sandy shale
479	485	Shale
485	536	Sandy shale
536	554	Tough shale
554	564	Fine sand
564	565	Rock
565	574	Sandy shale
574	576	Hard spot
576	597	Shale
597	602	Fine sand
602	603	Rock
603	628	Tough shale
628	647	Fine sand
647	755	Tough shale
755	756	Rock
756	783	Sand with streak of sand
783	807	Fine sand

Deep Well Number 2 (continued)

Elev - Feet From	To	Description
807	814	Tough shale
814	827	Fine sand, streaks of shale
827	837	Fine hard sand
837	841	Tough shale
841	855	Sandy shale
855	857	Rock
857	861	Shale
861	863	Shale and boulders
863	895	Sandy shale
895	905	Tough gumbo
905	915	Fine sand, salt and pepper
915	937	Fine sand, salt and pepper
937	981	Fine salt and pepper sand
981	998	Medium salt and pepper sand
998	1001	Break
1001	1004	Sand
1004	1007	Break, lignite
1007	1026	Medium salt and pepper sand
1026	1028	Break, lignite
1028	1040	Medium salt and pepper sand
1040	1062	Tough shale
1062	1065	Fine sand
1065	1070	Shale
1070	1076	Fine sand
1076	1084	Tough shale
1084	1087	Sandy shale
1087	1104	Fine sand
1104	1136	Coarse, deep, salt and pepper sand
1136	1144	Tough gumbo
1144	1170	Real fine, hard packed sand

BORING LOGS
DEEP WELLS
PINE BLUFF ARSENAL

Deep Well Number 1

Elev - Feet From	To	Description
0	7	Soil
7	95	Sand
95	140	Shale
140	185	Sandy shale
185	255	Sand
255	272	Hard sandy shale
272	273	Rock
273	350	Sandy shale
350	378	Shale (with boulders)
378	428	Sandy shale
428	450	Shale
450	459	Shale with streaks of sand
459	461	Rock
461	487	Tough shale
487	570	Sandy shale
570	588	Tough shale
588	596	Sand
596	618	Shale with streaks of sand
618	675	Shale
675	737	Tough shale
737	743	Sand
743	761	Shale
761	765	Fine sand
765	767	Tough shale
767	773	Fine sand
773	779	Tough shale
779	799	Fine sand
799	804	Hard shale
804	814	Fine sand
814	817	Hard shale
817	847	Sandy shale with streaks of sand
847	848	Break
848	870	Shale with streaks of sand
870	890	Fine sand with hard streaks
890	897	Tough gumbo
897	939	Fine hard sand
939	980	Fine hard sand
980	1070	Hard salt and pepper sand
1070		Sand

Deep Well Number 3

Elev - Feet From	To	Description
0	2	Soil
2	26	Sandy soil
26	38	Coarse brown sand
38	74	Fine red sand
74	94	Coarse red sand
94	198	Fine muddy sand
198	226	Shale
226	234	Fine sand
234	258	Sandy shale
258	276	Fine muddy sand
276	277	Boulders
277	286	Fine muddy sand
286	287	Boulders
287	292	Fine hard sand
292	323	Soft gummy shale
323	324	Hard rock
324	349	Shale
349	363	Shale with hard streaks
363	365	Rock
365	370	Shale
370	428	Sandy shale
428	438	Shale with streak of sand
438	461	Fine sand
461	466	Shale with streak of sand
466	516	Soft shale
516	530	Fine sand
530	539	Sandy shale
539	557	Fine sand
557	558	Rock
558	593	Sand and shale
593	594	Rock
594	616	Sand and shale
616	638	Fine sand
638	673	Shale
673	675	Rock
675	719	Tough shale
719	720	Rock
720	733	Tough shale
733	734	Rock
734	764	Tough shale
764	785	Fine salt and pepper sand

Deep Well Number 3 (continued)

Elev - Feet From	To	Description
785	813	Coarse, deep salt and pepper sand
813	817	Break, sandy shale
817	818	Boulders
818	825	Fine sand
825	829	Sand
829	832	Break
832	991	Good salt and pepper sand
991	993	Break, shale
993	1008	Good sand
1008	1023	Sand, mixed about half and half lignite
1023	1047	Shale, lignite, streak sand

Deep Well Number 14

Elev - Feet From	To	Description
0	25	Sandy clay
25	31	Soap stone
31	65	Real fine sand
65	160	Sandy shale
160	161	Rock
161	209	Shale
209	210	Rock
210	223	Shale
223	224	Rock
224	255	Shale
255	256	Rock
256	321	Sandy shale
321	360	Shale
360	445	Sandy shale
445	446	Rock
446	460	Sandy shale
460	485	Gumbo
485	613	Shale
613	712	Medium coarse sand
712	716	Sandy shale
716	751	Real fine hard packed sand
751	754	Break
754	806	Medium sand
806	835	Gumbo and boulders
835	836	Rock
836	855	Gumbo
855	883	Sandy shale
883	953	Medium coarse sand
953	989	Shale and gumbo

Deep Well Number 15

Elev - Feet From	To	Description
0	26	Sandy clay
26	100	Soft shale
100	172	Sandy shale
172	173	Rock
173	220	Shale
220	252	Gumbo
252	253	Rock
253	260	Sandy shale
260	261	Rock
261	271	Shale
271	272	Rock
272	315	Shale
315	360	Sandy shale
360	430	Shale
430	467	Sandy shale
467	468	Rock
468	604	Hard shale
604	605	Rock
605	626	Shale
626	627	Rock
627	688	Gumbo
688	692	Sand
692	694	Break
694	722	Hard salt and pepper sand
722	735	Real fine hard sand
735	767	Hard medium salt and pepper sand
767	769	Break
769	795	Hard medium salt and pepper sand
795	822	Gumbo
822	824	Boulders
824	838	Shale
838	852	Real fine sand
852	854	Break
854	876	Sand streaked with shale
876	1016	Good medium salt and pepper sand
1016		Gumbo

Deep Well Number 16

Elev - Feet From	To	Description
0	60	Sandy clay
60	68	Real fine sand
68	170	Gumbo
170	171	Rock
171	248	Gumbo
248	249	Rock
249	255	Gumbo
255	258	Boulders
258	274	Gumbo
274	275	Rock
275	287	Shale
287	288	Rock
288	376	Shale
376	400	Fine sand
400	444	Shale
444	445	Rock
445	498	Shale
498	545	Sandy shale
545	608	Gumbo
608	609	Rock
609	695	Gumbo
695	710	Sandy shale
710	750	Fine sand
750	753	Shale
753	794	Fine hard sand
794	855	Sandy shale
855	869	Fine sand
869	885	Sandy shale
885	987	Fine hard sand
987	989	Break
989	1048	Fine salt and pepper sand
Stopped in Gumbo		

Deep Well Number 17

Elev - Feet From	To	Description
0	8	Sandy clay
8	30	Clay
30	33	Sand
33	68	Clay
68	73	Sand
73	163	Clay
163	168	Fine sand
168	189	Shale
189	200	Shale and boulders
200	242	Shale
242	243	Rock
243	271	Shale
271	294	Shale and boulders
294	301	Shale
301	312	Rock
312	410	Shale
410	423	Medium sand
423	431	Shale
431	445	Sand streaked with shale
445	448	Shale
448	450	Rock
450	469	Hard shale
469	470	Rock
470	587	Hard shale
587	600	Sandy shale
600	617	Shale streaked with sand
617	663	Fine sand streaked with shale
663	704	Shale
704	724	Fine hard sand
724	757	Hard packed medium sand
757	765	Break
765	835	Hard medium packed sand
835	867	Shale
867	936	Real fine, hard sand
936	960	Sandy shale

Deep Well Number 18

Elev - Feet From	To	Description
0	25	Sandy clay
25	31	Hard clay
31	41	Medium sand
41	90	Sandy shale
90	140	Gumbo
140	215	Sandy shale
215	246	Gumbo
246	247	Rock
247	273	Gumbo
273	274	Rock
274	278	Gumbo
278	279	Rock
279	302	Shale
302	303	Rock
303	390	Shale
390	391	Rock
391	448	Shale
448	449	Rock
449	525	Sandy shale
525	586	Hard shale
586	587	Rock
587	669	Hard shale
669	696	Sandy shale
696	779	Medium sand
779	785	Break
785	813	Medium sand
813	814	Break
814	832	Medium sand
832	872	Shale

APPENDIX E

FAUNA AND FLORA

BIOTA OF PINE BLUFF ARSENAL AREA

FAUNA

Mammals

Common Name	Scientific Name
Carolina short-tailed shrew	Blarina brevicauda carolinensis
Coyote	Canis latrans
Mississippi Valley red wolf	Canis niger gregori
Beaver	Castor canadensis
Least shrew	Cryptotis parva
Nine banded armadillo	Dasypus Novemcinctus
Virginia opossum	Didelphis marsupialis virginiana
Oklahoma pocket gopher	Geomys bursarius dutcheri
Flying squirrel	Glaucomys volans
Northern red bat	Lasiurus borealis borealis
Bobcat	Lynx rufus
Striped skunk	Mephitis mephitis
Pine vole	Microtus pinetorum
House mouse	Mus musculus
Missouri weasel	Mustela frenata primulina
Large brown mink	Mustela vison mink
Whitetail deer	Odocoileus virginianus
Muskrat	Ondatra zibethicus
Texas rice rat	Oryzomys palustris texensis
Cotton mouse	Peromyscus gossypinus megacephalus
Southern white-footed mouse	Peromyscus leucopus leucopus

Mammals (continued)

Common Name	Scientific Name
Deer mouse	Peromyscus maniculatus
Golden mouse	Peromyscus nuttalli flammeus
Raccoon	Procyon lotor
Norway rat	Rattus norvegicus
Harvest mouse	Reithroden tormys fulvescens
Arkansas mole	Scalopus aquaticus pulcher
Gray squirrel	Sciurus carolinensis carolinensis
Fox squirrel	Sciurus niger rufiventer
Hispid cotton rat	Sigmodon hispidus hispidus
Eastern spotted skunk	Spilogale putorius
Swamp rabbit	Sylvilagus aquaticus
Cottontail rabbit	Sylvilagus floridanus alacer
Wisconsin gray fox	Urocyon cinereoargenteus ocythous
Red fox	Vulpes fulva

Birds

Cooper's hawk	Accipiter cooperi
Sharp-shinned hawk	Accipiter striatus
Spotted sandpiper	Actitis macularia
Red wing	Agelaius phoeniceus
Wood duck	Aix sponsa
Pintail	Anas acuta
Blue-winged teal	Anas discors
Mallard	Anas platyrhynchos

Birds (continued)

Common Name	Scientific Name
Black duck	Anas rubripes
Water pipit	Anthus spinoletta
Ruby-throated hummingbird	Archilocus colubris
Great blue heron	Ardea herodias
Lesser scaup	Aythya affinis
Ring-necked duck	Aythya collaris
Cedar waxwing	Bombycilla cedrorum
Canada goose	Branta canadensis
Great horned owl	Bubo virginianus
Red-tailed hawk	Buteo jamaicensis
Red-shouldered hawk	Buteo lineatus
Broad-winged hawk	Buteo platypterus
Wilson's snipe	Capella gallinago
Chuck-Will's widow	Caprimulgus carolinensis
Whip-Poor-Will	Caprimulgus vociferus
Purple finch	Carpodacus purpureus
American egret	Casmerodius albus
Turkey vulture	Cathartes aura
Red-bellied woodpecker	Centurus carolinus
Brown creeper	Certhia familiaris
Chimney swift	Chaetura pelagica
Blue goose	Chen caerulescens
Snow goose	Chen hyperborea
Black tern	Chlidonias niger

Birds (continued)

Common Name	Scientific Name
Nighthawk	Chordeiles minor
Marsh hawk	Circus cyaneus
Yellow-billed cuckoo	Coccyzus americanus
Flicker	Colaptes auratus
Bob-white quail	Colinus virginianus
Eastern wood pewee	Contopus virens
Black vulture	Coragyps atratus
Common crow	Corvus brachyrhynchos
Fish crow	Corvus ossifragus
Blue jay	Cyanoeitta cristata
Red-cockaded woodpecker	Dendrocopes borealis
Downy woodpecker	Dendrocopes pubescens
Hairy woodpecker	Dendrocopes villosus
Bay-breasted warbler	Dendroica castanea
Cerulean warbler	Dendroica cerulea
Yellow-rumped warbler	Dendroica coronata
Prairie warbler	Dendroica discolor
Yellow-throated warbler	Dendroica dominioa
Blackburnian warbler	Dendroica fusca
Magnolia warbler	Dendroica magnolia
Chestnut-sided warbler	Dendroica pennsylvanica
Yellow warbler	Dendroica petechia
Pine warbler	Dendroica pinus
Black-poll warbler	Dendroica striata

Birds (continued)

Common Name	Scientific Name
Black-throated green warbler	Dendroica virens
Pileated woodpecker	Dryocopus pileatus
Catbird	Dumetella carolinensis
Least flycatcher	Empidonax minimum
Acadian flycatcher	Empidonax virescens
Rusty blackbird	Euphagus carolinus
Duck hawk	Falco peregrinus
Kestrel	Falco sparverius
Little blue heron	Florida caerulea
Coot	Fulica americana
Yellow-throat	Geothlypis trichas
Blue grosbeak	Guiraca caerulea
Bald eagle	Haliacetus leucocephalus
Worm-eating warbler	Helmitheros vermivorus
Caspian tern	Hydroprogne caspia
Veery	Hylocichla fuscescens
Hermit thrush	Hylocichla guttata
Gray-cheeked thrush	Hylocichla minima
Wood thrush	Hylocichla mustelina
Olive-backed thrush	Hylocichla ustulata
Yellow-breasted chat	Icteria virens
Northern oriole	Icturus glabula
Orchard oriole	Icturus spurius
Slate-colored junco	Junco hyemalis

Birds (continued)

Common Name	Scientific Name
Loggerhead shrike	Lanius ludovicianus
Ring-billed gull	Larus delawarensis
Belted kingfisher	Megaceryle alcyon
Red-headed woodpecker	Melanerpes erythrocephalus
Turkey	Meleagris gallopavo
Swamp sparrow	Melospiza georgiana
Lincoln's sparrow	Melospiza lincolnii
Song sparrow	Melospiza melodia
Mockingbird	Mimus polyglottos
Black and white warbler	Mniotilta veria
Cowbird, abundant	Molothrus ater
Crested flycatcher	Myiarchus crinitus
Kentucky warbler	Oporornis formosus
Screech owl	Otus asio
Osprey	Pandion haliaetus
Parula warbler	Parula americana
Tufted titmouse	Parus bicolor
Carolina chickadee	Parus carolinensis
English sparrow	Passer domesticus
Savannah sparrow	Passerculus sandwichensis
Fox sparrow	Passerella iliaca
Leconte's sparrow	Passerherbulus caudactus
Henslow's sparrow	Passerherbulus henslowi
Indigo bunting	Passerhirina cyanea

Birds (continued)

Common Name	Scientific Name
White pelican	Pelecanus erythrorhynchos
Double-crested carmorant	Phalacrocorax auritus
Rose-breasted grosbeak	Pheuticus ludovicianus
Woodcock	Philohela minor
Red-eyed towhee	Pipilo erythrophthalmus
Summer tanager	Piranga rubra
Pied-billed grebe	Polilymbus podiceps
Blue-gray gnatcatcher	Polioptila caerulea
Purple martin	Progne subis
Prothonotary warbler	Protonotaria citrea
Common grackle	Quiscalus quiscula
Ruby-crowned kinglet	Regulus calendula
Golden-crowned kinglet	Regulus satrapa
Cardinal	Richmondena cardinalis
Eastern phoebe	Sayornis phoebe
Ovenbird	Seiurus aurocapillus
Louisiana water-thrush	Seiurus motacilla
American redstart	Setophaga ruticilla
Eastern bluebird	Sialia sialis
White-breasted nuthatch	Sitta carolinensis
Yellow-bellied sapsucker	Sphyrapicus varius
Pine siskin	Spinus pinus
Goldfinch	Spinus tristis
Chipping sparrow	Spizella passerina

Birds (continued)

Common Name	Scientific Name
Field sparrow, common	Spizella pusilla
Rough-winged swallow	Stelgidopteryx ruficollis
Barred owl	Strix varia
Eastern meadowlark	Sturnella magna
Starling	Sturnus vulgaris
Bewick's wren	Thyromanes bewickii
Carolina wren	Thyrothorus lucovicianus
Brown thrasher	Toxostoma rufum
Solitary sandpiper	Tringo solitaria
Winter wren	Toglodytes troglodytes
Robin	Turdus migratorius
Eastern kingbird	Tyrannus tyrannus
Orange-crowned warbler	Vermivora celata
Golden-winged warbler	Vermivora chrysoptera
Tennessee warbler	Vermivora peregrina
Nashville warbler	Vermivora ruficapilla
Yellow-throated vireo	Vireo flavifrons
Warbling vireo	Vireo gilvus
White-eyed vireo	Vireo griseus
Red-eyed vireo	Vireo olivaceus
Solitary vireo	Vireo solitarius
Canada warbler	Wilsonia canadensis
Hooded warbler	Wilsonia citrina
Wilson's warbler	Wilsonia pusilla

Birds (continued)

Common Name	Scientific Name
Mourning dove	Zenaidura macroura
White-throated sparrow	Zonotrichia albicollis
White-crowned sparrow	Zonotrichia leocophrys

Fish

(1) Species found in ponds and lakes on the Arsenal

Drum	Aplodinotus grunniens
Warmouth	Chaenobryttus gulosus
Carp	Cyprinus carpio
Chain pickerel	Esox niger
Yellow bullhead	Ictalurus natalis
Channel catfish	Ictalurus punctatus
Shortnose gar	Lepisosteus platostomus
Yellowbelly sunfish	Lepomis auritus
Green sunfish	Lepomis cyanellus
Pumpkinseed sunfish	Lepomis gibbosus
Bluegill sunfish	Lepomis macrochirus
Longear sunfish	Lepomis megalotis
Redear sunfish	Leopmis microlophus
Largemouth bass	Micropterus salmoides
Paddlefish	Polydon spathula

Fish (continued)

(2) Species found only in the Arkansas River, bordering the Arsenal, and in Yellow Lake, which is occasionally completely inundated by the Arkansas River floodwaters

Common Name	Scientific Name
Gizzard shad	Dorosoma cepedianum
Blue catfish	Ictalurus furcatus
Black bullhead	Ictalurus melas
Brown bullhead	Ictalurus nebulosus
Smallmouth buffalo	Ictiobus bubalus
Bigmouth buffalo	Ictiobus cyprinellus
Black buffalo	Ictiobus niger
Alligator gar	Lepisosteus spatula
Spotted bass	Micropterus punctulatus
White crappie	Pomoxis annularis
Black crappie	Pomoxis nigromaculatus
Flathead catfish	Pylodictis olivaris
Shovelnose sturgeon	Schaphirhynchus platorynchus

Reptiles and Amphibians

Snakes

Southern copperhead	Agkistrodon contortrix contortrix
Cottonmouth	Agkistrodon piscivorus
Wormsnake	Carphophis amoenus
Scarlet snake	Cemophora coccinea
Black racer	Colubar contrictor
Timber rattlesnake	Crotalus horridus

Snakes (continued)

Common Name	Scientific Name
Southern ring-necked snake	Diadophis punctatus punctatus
Black rat snake	Elaphe obsoleta obsoleta
Mud snake	Farancia abacura
Rough earthsnake	Haldea striatula
Smooth earthsnake	Haldea valeria
Eastern hog-nosed snake	Heterodon platyrhinos
Priarie kingsnake	Lampropeltis calligaster
Speckled kingsnake	Lampropeltis getulus holbrooki
Eastern coachwhip	Masticophis flagellum
Red-bellied watersnake	Natrix erythrogaster erythrogaster
Yellow-bellied watersnake	Natrix erythrogaster flavigaster
Diamond-backed watersnake	Natrix rhombifera rhombifera rhombifera
Northern watersnake	Natrix sipedon sipedon
Rough greensnake	Opheodrys aestivus
Pigmy rattlesnake	Sistrurns miliarius
Northern brownsnake	Storeria dekayi
Red-bellied snake	Storeria occipitomaculata
Eastern gartersnake	Thamnophis sirtailis sirtalis
Eastern ribbonsnake	Thamnophis sauritus

Turtles

Snapping turtle	Chelydra serpentina
Southern painted turtle	Chrysemys picta dorsalis
Map turtle	Graptemys geographica
False map turtle	Graptemys pseudogeographica

Turtles (continued)

Common Name	Scientific Name
Mudturtle	Kinosternon subrubrum
Alligator snapping turtle	Macroclemys temmincki
Cooter	Pseudemys floridana concinna
Red-eared turtle	Pseudemys scripta elegans
Stinkpot	Sternotherus odoratus
Box turtle	Terrapene carolina
Smooth softshell turtle	Trionyx muticus

Lizards

Six-lined racerunner	Cnemidophorus sexlineatus
Five-line skink	Eumeces fasiatus
Broad-headed skink	Eumeces laticeps
Ground skink	Lygosoma laterale
Slender glass lizard	Ophisaurus attenuatus
Eastern fence lizard	Sceloporus undulatus

Salamanders

Spotted salamander	Ambystoma maculatum
Marbled salamander	Ambystoma opacum
Small-mouthed salamander	Ambystoma texanum
Dusky salamander	Desmognathus fuscus
Central newt	Diemictylus viridescens
Mudpuppy	Necturus maculosus
Slimy salamander	Plethodon glutinosus

Salamanders (continued)

Common Name	Scientific Name
Lesser siren	Siren intermedia

Toads and Frogs

American toad	Bufo terrestris
Dwarf American toad	Bufo americanus charlesmithi
Woodhouse's toad	Bufo woodhousei
Green tree frog	Hyla cinerea
Spring peeper	Hyla crucifer
Gray tree frog	Hyla versicolor
Bullfrog	Rana catesbeiana
Pickerel frog	Rana palustris
Leopard frog	Rana pipiens

FAUNA (continued)

Invertebrate taxa collected in streams on the Arsenal
from July 1973 through November 1974

Arthropoda

Insecta

Coleoptera (beetles)

Dytiscidae (predaceous diving beetles)

Hydroporus sp.

Diptera (true flies)

Ceratopogonidae (biting midges)

Palpomyia spp.

Culicidae; chaoborinae (phantom midges)

Chaoborus punctipennis

Chironomidae (midges)

Anatopynia sp. 1 (nr)*

Calopsectra sp.

Chironomus modestus

Chironomus riparius (nr)

Clinotanypus thoracicus (nr)

Glyptotendipes senilis

Hydrobaenus sp. 2

Pentaneura carnea (nr)

Pentaneura monilis

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*(nr) indicates that identification is considered to be near this species; however, the description of the species itself may include several taxa.

Insecta (continued)

Chironomidae (midges) (continued)

Polypedilum halterale (nr)

Polypedilum illinoense

Procladius adumbratus (nr)

Procladius culiciformis

Psectrocladius flavus

Tanypus neopunctipennis

Simuliidae (black flies)

Simulium vittatum

Tipulidae (crane flies)

Chrysops sp.

Tipula spp.

Ephemeroptera (mayflies)

Baetidae

Caenis spp.

Neocloeon alamance

Ephemeridae

Hexagenia limbata

Heptageniidae

Stenonema tripunctatum

Hemiptera (true bugs)

Belostomatidae (giant water bugs)

Belastoma sp.

Odonata

Anisoptera (dragonflies)

Odonata (continued)

Calopterygidae

Calopteryx maculata

Cordulegasteridae

Cordulegaster sp.

Libellulidae

Celithemis eponina

Erythemis simplica

Erythemis simplicollis

Erythrodiplax minuscula

Libellula spp.

Libellula luctuosa

Libellula vibrans

Macromia magnifica

Pachydiplax longipennis

Pantala flavescens

Pantala hymenea

Plathemis sp.

Plathemis lydia

Perithemis tenera

Tetragoneuria cynosura

Coenagrionidae (damselflies)

Anomalagron hastatum

Argia spp.

Argia apicalis

Insecta (continued)

Coenagrionidae (damselflies) (continued)

Argia fumipennis

Argia moesta

Coenagrion spp.

Enallagma basidens

Enallagma civile

Enallagma cyathigerum

Enallagma divagans

Enallagma signatum

Ischnura ramburii

Plecoptera (stoneflies)

Perlidae

Perlesta spp.

Nemouridae

Nemoura spp.

Trichoptera (caddisflies)

Hydropsychidae

Potamyia flava

Lepidoptera (aquatic moths)

Pyralidae unknown

Crustacea

Isopoda (aquatic sow bugs)

Asellidae

Asellus obtusus

Crustacea (continued)

Asellidae (continued)

Asellus dentadactylus

Amphipoda (side swimmers, scuds)

Gammaridae

Synurella bifurca

Hyalellidae

Hyalella azteca

Decapoda

Palaemonidae (grass shrimp)

Palaemonetes kadiakensis

Astacidae (crayfish)

Oronectes palmeri longimanus

Procambarus ouachitae

Procambarus clarkii

Procambarus immatures

Annelida

Oligochaeta

Tubificidae (sludge worms)

Limnodrilus hoffmeisteri

Stylaria fossularis

Hirudinea (leeches)

Glossiphonidae

Placobdella parasitica

Piscicolidae

Piscicola sp.

Mollusca

Pelecypoda (clams)

Sphaeriidae (finger nail clams)

Sphaerium transversum

Gastropoda (snails)

Physidae (pouch snails)

Physa spp.

Lymnaeidae (pond snails)

Limnaea spp.

Ancylidae (limpets)

Ferrissa sp.

Planorbidae (orb snails)

Gyraulus sp.

Platyhelminthes

Turbellaria (flat worms)

Planariidae (planaria)

Dugesia tigrina

FLORA

Trees

Common Name	Scientific Name
Box elder	Acer negundo
Red maple	Acer rubrum
Silver maple	Acer saccharinum
River birch	Betula nigra
Hophornbeam	Carpinus caroliniana
Pecan	Carya illinoensis
Black hickory	Carya texana arkansas
Mokernut hickory	Carya tomentosa
Chinquapin	Castanea pumila
Hackberry	Celtis laevigata
Dogwood	Cornus florida
Persimmon	Diospyros virginiana
White ash	Fraxinus americana
Green ash	Fraxinus pennsylvanica
American holly	Ilex opaca
Sweet gum	Liquidambar stryaciflua
Black gum	Nyssa sylvatica
Shortleaf pine	Pinus echinata
Loblolly pine	Pinus taeda
Sycamore	Platanus occidentalis
Cottonwood	Populus deltoides
White oak	Quercus alba
Red oak	Quercus falcata

Trees (continued)

Common Name	Scientific Name
Water oak	Quercus nigra
Willow oak	Quercus phellos
Post oak	Quercus stellata
Black willow	Salix nigra

Shrubs

Buckeye	Aesculus discolor
Hawthorn	Crataegus viridis
Dwarf huckleberry.	Gaylussacia dumosa
Eastern redcedar	Juniperus virginiana
Honeysuckle	Lonicera spp.
Wildplum	Prunus angustifola
Shining sumac	Rhus copallina
Poison ivy	Rhus radicans
Blackberry	Rubus spp.
Dewberry	Rubus spp.
Greenbrier	Smilax spp.
Winter huckleberry	Vaccinium aboreom
Grape	Vitis spp.

Grasses

Fescue grass	Bromus catharticus
Smooth brome	Bromus inermis
Bermuda grass	Cynodon dactylon

Grasses (continued)

Common Name	Scientific Name
Orchard grass	Dactylis glomerata
Barnyard grass	Exhinochloa crusgalli
Rye grass	Lolium multiflorum
Blue panic	Panicum antodotale
Torpedo grass	Panicum repens
Dallis grass	Paspalum malacophyllum
Field pasnalum	Paspalum laeve
Ribbed paspalum	Paspalum malacophyllum
Vasey grass	Paspalum urvillei
Yellow bristlegrass	Setaria glauca
Johnson grass	Sorghum halepense
Sorghum	Sorghum vulgare

Legumes

Singletary pea	Lathyrus hirsutus
Sericea lespedeza	Lespedza cuneata
Korean lespedeza	Lespedeza stipulacea
Kobe lespedeza	Lespedeza striata
Spotted bur-clover	Medicage arabica
Little bur-clover	Medicago minima
Alfalfa	Medicago sativa
Alsika clover	Trifolium hybridum
Crimson clover	Trifolium incarnatum
Ball clover	Trifolium nigrescens

Legumes (continued)

Common Name	Scientific Name
Red clover	Trifolium pratense
White clover	Trifolium repens
Voollypod vetch	Vicia dasycarpa
Hungarian vetch	Vicia pannonica
Common vetch	Vicia sativa
Hairy vetch	Vicia villosa

Weeds

Foxtail	Alopecurus pratensis
Ragweed	Ambrosia psilostachya
Partridgepea	Chamaecrista fascieulata
Tickclover	Desmodium sessilifolium
Pokeberry	Phytolacca americana
Smartweed	Polygonum pensylvanicum
Sogo pondweed	Potamogeton pectinatus
Dandelion	Taraxacum officinale

APPENDIX F

DRAFT EDGEWOOD ARSENAL TECHNICAL REPORT

TERRESTRIAL ECOLOGICAL SURVEYS AT PINE BLUFF ARSENAL

FEBRUARY 1977

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

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Wildlife	Reptiles
Plants	Amphibians
Mammals	Pine Bluff Arsenal
Birds	Land Contamination

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The results from two terrestrial ecological surveys at Pine Bluff Arsenal, Pine Bluff, Arkansas, indicated that most of the biological commities are healthy and normal, despite gross localized contamination. The largest areas of disturbance are caused by a combination of decontamination products, munition wastewaters, and pesticides. Studies of vertebrate populations showed that there were no significant differences in their abundances between contaminated and reference areas. Future studies were recommended to include broaccumulation and the effect of contamination of soil invertebrates.

EDGEWOOD ARSENAL TECHNICAL REPORT

TERRESTRIAL ECOLOGICAL SURVEYS AT PINE BLUFF ARSENAL PINE BLUFF, ARKANSAS

EOTR
EQTR

DRAFT

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February 1977

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DISPOSITION

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PREFACE

The work described in this report was authorized under task 2, subproject 3, PAA 57X4114, Development of Methods to Minimize Environmental Contamination, Ecological Surveys of Environmental Conditions at USAMC installations. This is a three-phase program: phase I, Initial Site Visit, completed November 1972; phase II, Preliminary Environmental Survey, completed January 1973; and phase III, Ecological Surveys, initiated in January 1973. Phase III is divided into three separate aquatic surveys: (1) Pine Bluff Arsenal streams, initiated January 1973, completed July 1974; (2) Yellow Lake, initiated March 1974, completed January 1976, and (3) Production Area Drainages, initiated January 1975.

The data presented here were gathered during two terrestrial ecological surveys of phase III conducted in May and September, 1973.

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I. INTRODUCTION

Pine Bluff Arsenal (PBA), Arkansas, was constructed in 1941 for the manufacture, loading, and assembly of magnesium and thermite types of incendiary bombs. The initial mission was quickly expanded to include the manufacture of war gases and the filling of chemical bombs, incendiary smoke munitions, and other munitions with chemicals such as chlorine, mustard, and lewisite. Development of facilities for biological warfare operations began in 1953. Through the 1950's the Diamond Alkali and Chemical Company used facilities at PBA to make chlorine for use by Niagra Chemical Company (another contractor) which made DDT, ~~malathion, parathion, and~~ chlorobenzenes. Biological warfare activities were discontinued in 1969.[1]

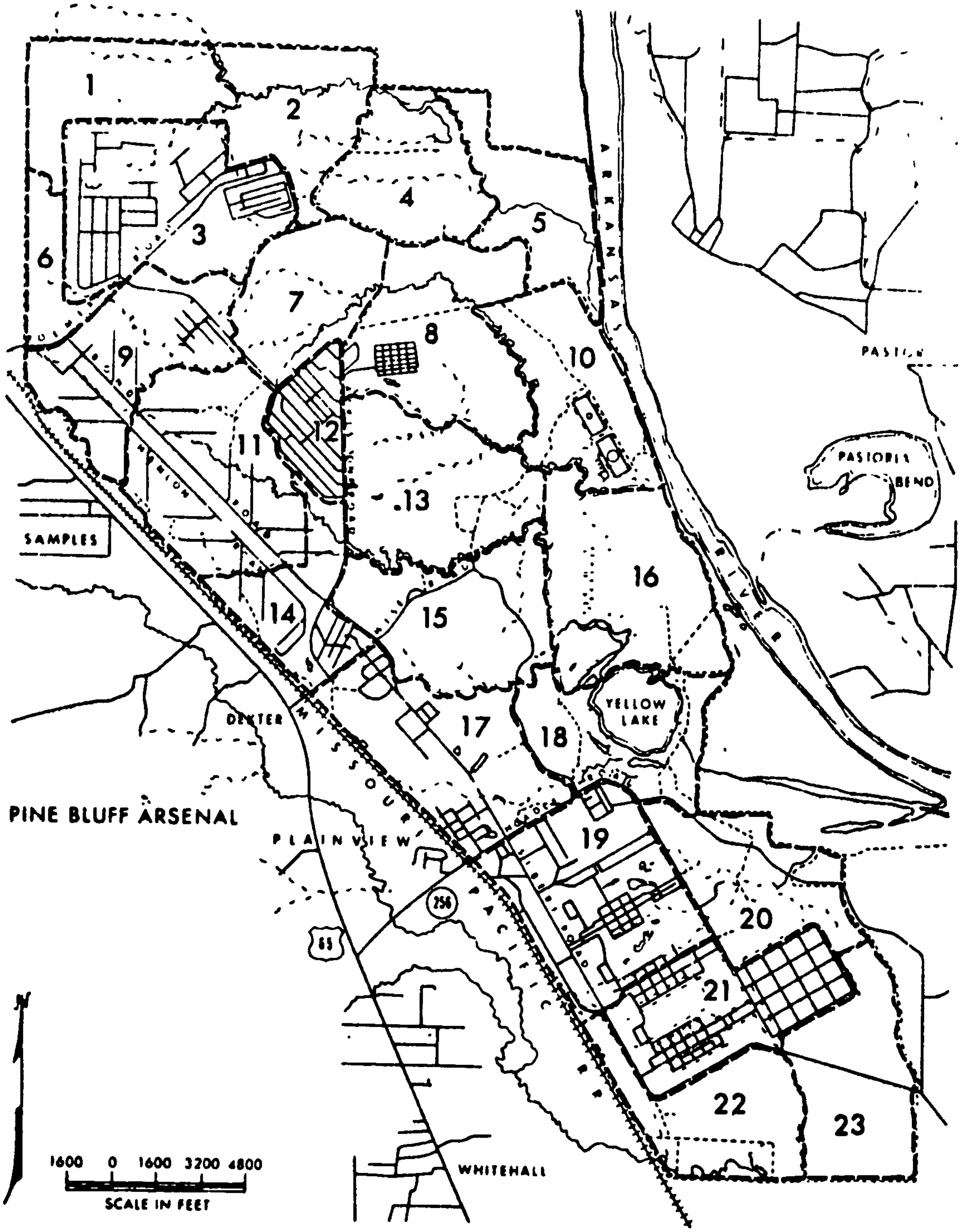
Ecological surveys were initiated to establish past and present affects of installation activities on the environment, as a baseline against which to compare the impact of a centralized pollution abatement facility scheduled for completion in FY 79. Little information was found on the terrestrial fauna and flora of the site during the preliminary environmental survey.[1] Therefore these surveys also were designed to expand and document a baseline of ecological conditions at PBA.

Problem areas were discovered and reported elsewhere.[2] This report concerns itself mainly with the terrestrial survey data and is not intended to be comprehensive; rather the data are published to serve as a baseline for environmental assessments and for future ecological comparisons.

A. Survey Sectors

Maps were used for each of the surveys which divide the installation into 23 sectors, the boundaries of which were distinguishable on the ground as roadways or prominent stream drainages. (Fig. 1). An attempt was made not to divide areas comprising major installation activities, (such as industrial or administrative areas) but rather, to examine these areas as individual sectors. (Table I)

Figure 1. Survey Sectors at Pine Bluff Arsenal



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ARKANSAS RIVER
PASTORIA BEND
SAMPLES
YELLOW LAKE
DEXTER
MISSOURI PACIFIC RR
PINE BLUFF ARSENAL
PLAINVIEW
256
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WHITEHALL
1600 0 1600 3200 4800
SCALE IN FEET

TABLE I.

MAJOR INSTALLATION ACTIVITY ON SURVEY SECTORS

SECTOR	ACTIVITY
1, 2, 4-7, 13, 16, 20, 22, 23	Woodlands managed for timber and recreation
3	National Center for Toxicological Research and Toxic Chemicals storage
8	Toxic chemicals storage, woodlands
9, 11, 14	Munitions storage
10	Munitions testing and open burning
12	Chemicals manufacturing and storage
15	Residential and woodlands
17	Administration
18	Munitions testing, recreation
19, 21	Munitions manufacturing and loading

The first group of sectors (reference sectors) are largely undisturbed. These sectors were compared with the remaining sectors (experimental sectors) which might have been modified by the activities occurring in them.

II. METHODS

B. Mammals

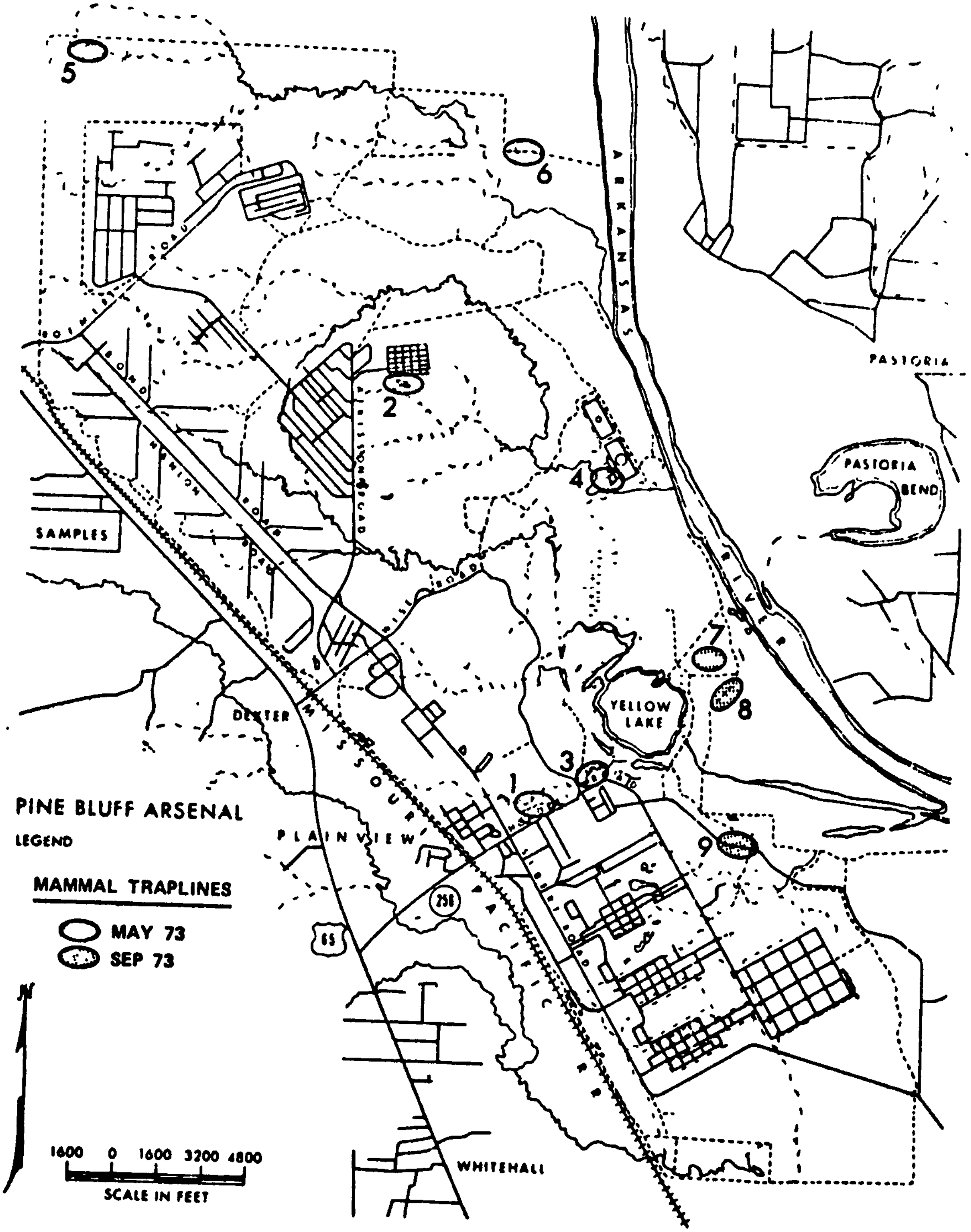
Mammals were surveyed using live-traps, and by observing them (or their signs) while walking through the sectors or while driving along installation roadways.

Six traplines were established in May 1973. Two lines (numbers 5 and 6) were located in remote areas, and four others were placed in suitable habitat near contaminated areas. Three more traplines were established in September 1973; numbers 7 and 8 along the Arkansas River floodplain, and number 9 in the area of the proposed Central Wastewater Treatment Facility. (Fig 2).

Traplines were set in the early afternoon according to the following schedule: lines 1 and 2 on the first of May; 1, 2, and 3 on the second; 2, 3, and 4 on the third; 3, 4, and 5 on the fourth; 3, 5, and 6 on the fifth; 5 and 6 on the sixth; and line 6 on the seventh. Trapline number 7 was set on the eithteenth and nineteenth of September; 8 on the nineteenth; and 9 on the nineteenth, twentieth, and twenty-first. Aluminum Sherman folding live-traps (9x4x3 and 6x4x3 inches) baited with peanut butter and grain were used for small mammals, and wooden live-traps (24x9x7 inches) baited with peanut butter or canned dog food for larger mammals. Wire traps were used for moles and gophers. The sampling intensity totaled 573 trap nights (the total number of nights ~~that~~ for all traps that were set). Each morning, captured animals were anesthetized with Methoxyflurane*, were identified[3] and sexed, their general condition was noted, and they were released at the site of capture.

*Forestry Suppliers, Inc., Jackson, Mississippi

Figure 2. Mammal Trapping Sites at Pine Bluff Arsenal


PINE BLUFF ARSENAL
LEGEND
MAMMAL TRAPLINES
MAY 73
SEP 73
1600 0 1600 3200 4800
SCALE IN FEET
N
ARKANSAS
RIVER
PASTORIA
PASTORIA BEND
YELLOW LAKE
SAMPLES
DEXTER
PLAINVIEW
MISSOURI PACIFIC RR
WHITEHALL
65
256
1
2
3
4
5
6
7
8
9

C. Birds

A survey of the birds at PBA was conducted during the daylight hours, on nine consecutive days from 30 April to 8 May, 1973. One night survey was conducted on 3 May during the twilight and evening hours. Species were identified from observation and by a distinctive call.[4] Both migrants and residents were included in the survey. Identifications were made by teams of biologists walking through the sectors, or from vehicles stopping periodically along installation roadways. These routes were not predefined. Equal effort was not devoted to each sector and hence the data are useful only for detecting gross qualitative differences in the species composition between sectors.

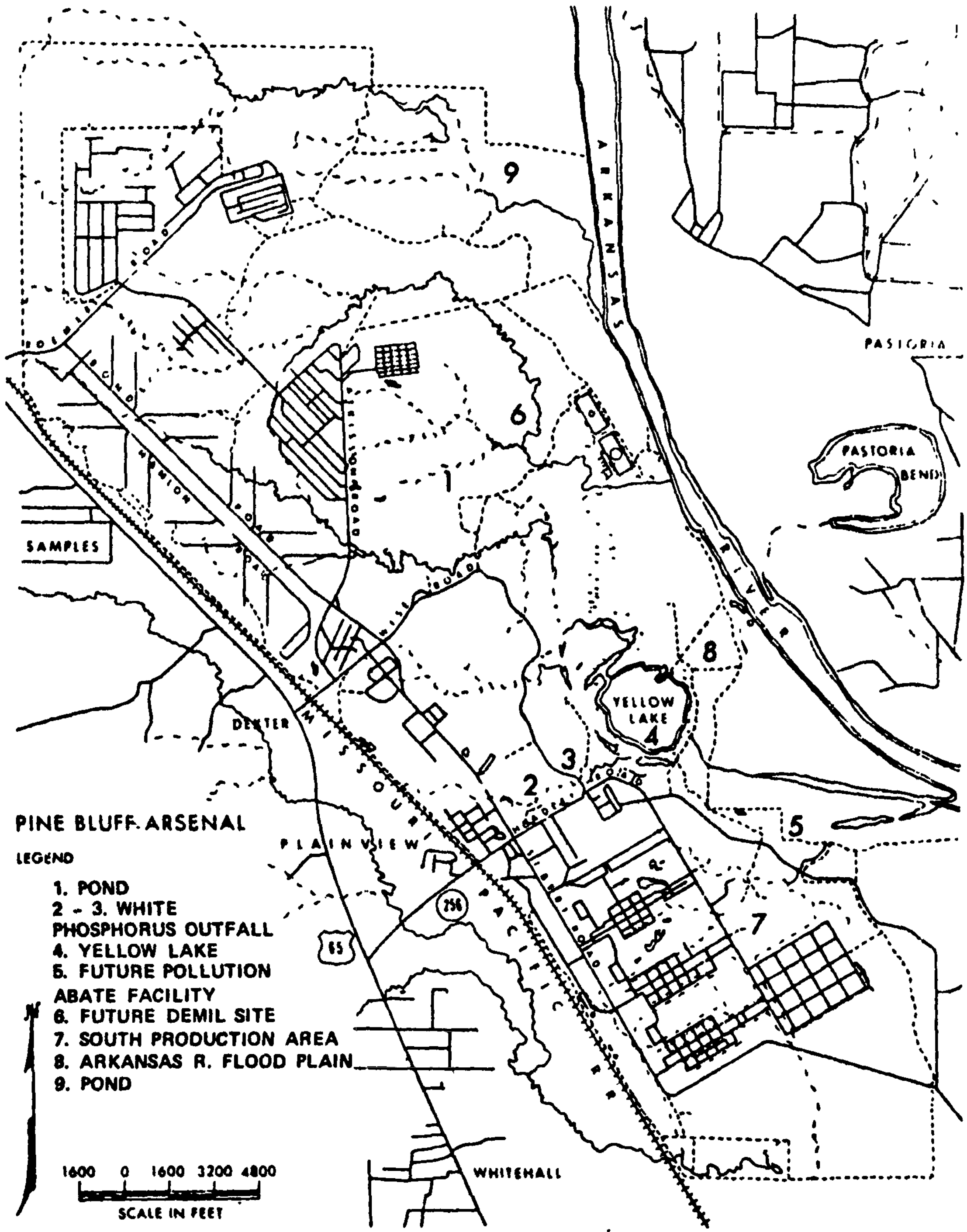
D. Reptiles and Amphibians

Species of reptiles and amphibians were identified,[5] and their capture location noted, whenever they were encountered (principally by overturning logs) during the surveys of other groups. Tadpoles were collected in temporary ponds in each sector with a dip net. Species of frogs and toads were also recorded when they could be identified by distinctive calls.

E. Plants

A list of vascular plants occurring at PBA was compiled by examining quadrats (100 square meters each) at various locations on the arsenal (Fig. 3). Additional species were included by driving along installation roadways and recording those species that had not been previously observed. The nomenclature follows Gray's Manual of Botany.[6]

Figure 3. Locations of the Plant Quadrats at Pine Bluff Arsenal


PINE BLUFF ARSENAL
LEGEND
1. POND
2 - 3. WHITE PHOSPHORUS OUTFALL
4. YELLOW LAKE
5. FUTURE POLLUTION ABATE FACILITY
6. FUTURE DEMIL SITE
7. SOUTH PRODUCTION AREA
8. ARKANSAS R. FLOOD PLAIN
9. POND
1600 0 1600 3200 4800
SCALE IN FEET
ARKANSAS RIVER
PASTORIA
PASTORIA BEND
YELLOW LAKE
SAMPLES
DEXTER
PLAINVIEW
MISSOURI PACIFIC RR
WHITEHALL
256
65

Several areas were investigated that appeared to have a disturbed flora and fauna as the result of land contamination from various industrial chemicals.

E. Statistical Analyses

A method of cluster analysis was used in this study to measure similarity between sectors. The first step in this method is to calculate a matrix of similarity values. Sneath and Sokal[7] provide an excellent review of many of the similarity values proposed in the literature. For our analysis we have chosen the Pinkham-Pearson index of biotic similarity,[8] which allows for comparison of sectors based on species abundance and occurrence. The equation for this index is:

$$B = \frac{1}{k} \sum_{i=1}^{k} \frac{\min(X_{ia}, X_{ib})}{\max(X_{ia}, X_{ib})}$$

where k is the number of different species in the samples and X_{ia} and X_{ib} are the number of individuals of the i^{th} species in sample a and b, respectively.

An important feature of this index is that it allows the user to omit matches in which a particular species is absent from both stations (zero-zero matches ignored) or to assign them the maximum value (zero-zero matches equal one). This allows the user to incorporate or exclude mutual absence type data when generating the similarity index depending upon the user's judgement as to the validity of these matches. For example, in a set of data in which there are many rare species, there would also be numerous spurious mutual absence type matches, therefore, the zero-zero matches ignored option would be the one of choice. However, if the rare occurrences were removed from these data for analysis, then mutual absence type matches would reflect actual similarity between stations and therefore, the "zero-zero matches equal one" option would be preferable.

The second step in cluster analysis is the actual clustering of the resultant similarity values. We have used an unweighted pair-group method which generally introduces less distortion into the clusters. A detailed discussion of this method and cluster analysis in general can be found in Sneath and Sokal.[7]

The next step is to display graphically the results of the cluster analysis. Tree-like structures called dendrograms are constructed for this purpose. The scale of similarity is shown across the top of the dendrogram, or tree, which is arranged with its "trunk" at the lowest level of similarity. The similarity level of any cluster may be determined by drawing a vertical line from the level of branching to the scale.

Generally two dendrograms are created from the same data, one for the cluster of surveillance sites and another for the cluster of survey dates. A cluster of species is also created when two or more species are involved. The original data are rearranged in a matrix with the axes in the order indicated by both dendrograms (double-dendrogram order). This results in data points with similar values being arranged together while still maintaining the integrity of the data obtained at the same surveillance sites or on the same survey date. Then a vertical line is drawn in each dendrogram which separates logical clusters of surveillance sites, survey dates or species.

The choice of the level of similarity at which the vertical line is drawn is somewhat arbitrary, although past experience has shown that lines above a similarity of 0.6, separate groups which usually are not significantly different.

Furthermore the choice is aided by examining the original data rearranged in double-dendrogram order. Lines are drawn through the rearranged data separating the data into subdivisions corresponding to the clusters in both dendrograms indicated by the positions of both vertical lines. Various vertical lines are attempted until logical subdivisions are identified. The vertical lines need not be drawn at the same degree of similarity throughout the dendrogram if more logical subdivisions are indicated by using two different degrees of similarity.

The resulting subdivisions are verified by testing the meaning of each subdivision against the means of all other subdivisions.

The last step is to measure the amount of distortion in the dendrogram caused by the cluster method. This is necessary because the clustering method involves averaging of similarity values in order to express the multidimensiona similarity matrix in a two-dimensional, heirarchic relationship. This is accomplished by computing a correlation coefficient between the original similarity values and the ones resulting from the dendrogram.[7] The correlation coefficient is a measure of the amount of distortion introduced by the clustering method.

Since strictly quantitative methods were not used in the bird census study, the data were rendered semiquantitative, i.e., species weighted as abundant = 3 present but not abundant = 1, and absent = 0. Using these values, only those species observed in three or more sectors and the "zero-zero matches ignored" option, the matrix of similarity values between sectors was calculated.

Statistical tests were conducted using the Student-Newman-Keul's test for differences between multiple means, the aposteriori test of the homogeneity of replicates of proportions or ratios and the chi-square, two-way contingency test for differences between pairs of proportions or ratios.[9] Unless otherwise noted, statistical tests were performed at the 0.05 level.

III. RESULTS

A. Mammals

A total of 13 species of mammals was recorded from 80 observations during the two trapping surveys, and from chance sightings. The signs of four more species were found yielding a total of 16 species of mammals known to occur at PBA (Table II). The most frequently observed species included the White-Tailed Deer, Cotton Rat, White-Footed Mouse, and the Fox Squirrel. There is no statistical difference between the ratios of mammals observed in the reference areas over all sectors.

Results of the mammal trapping survey are presented in Table III. Results of tests of significance on the rates of trapping success are presented in Table IV. success in All areas were was low, but the area with the highest success, 8, was found to be significantly higher than area 5, with the lowest success.

B. Birds

Sightings of 775 birds comprising 68 species, were recorded during the survey. These species are listed in Appendix 1, along with the sectors in which they were found.

Species encountered five or more times in the same sector during the same day were recorded as being abundant in that sector. Fourteen such species were found to be abundant in one or more survey sectors. The dendrograms of species and sectors are given in Figures 4 and 5. The clusters in the species dendrogram are based primarily upon habitat preferences: Those birds found in cluster A are ones usually found in field margins and fields with bushes. Those in B are usually birds of open fields. Those in C are usually birds of open woods, while those in D are usually birds of dense woods and wood-field ecotones. Lastly cluster E birds are usually found in suburbs and farmlands. The significance of the clusters of sectors will be discussed shortly.

The original data were rearranged in double dendrogram order (Table V) and the clusters from the dendrograms were superimposed creating 15 subdivisions. Table VI presents the results of the tests of these means. Subdivisions 2B-2A have significantly lower means than subdivisions 2D - 1E, with 1B and 3E qualifying for either group of subdivisions. Table VII illustrates the significance of these findings. With the possible exception of species cluster B, all the species in sector cluster 1 were found in significantly high numbers. Sector cluster 2 showed high representation in species cluster D indicating those sectors are primarily heavily wooded. As might be expected from the similarily of habitat preference, clusters of species A and C showed the same result.

C. Reptiles and Amphibians

Eight amphibians and 15 reptile species were recorded from 108 sightings during the survey. These species, and the sectors in which they were found are listed in Table VIII. There was no significant difference between the ratio of reptiles and amphibians in the reference sectors over all species observed and the ratio of reference sectors over all sectors.

Tadpoles were collected in ponds and flowing water as they were encountered in each sector. Their occurrence along with that of aquatic invertebrates was used to evaluate the suitability of these waters to sustain aquatic life. The results of the aquatic investigations in sectors 7, 8, 12, and 13 are detailed in an earlier publication.[2]

D. Plants

A list of vascular plants that were found at PBA during the survey period is included as Table IX.

Several areas were located that have a highly distributed vegetative cover, which is likely due to several types of soil contamination.[2]

Appendix 1. Birds Observed at Pine Bluff Arsenal

Appendix 1.

BIRDS OBSERVED AT PINE BLUFF ARSENAL

COMMON NAME	SCIENTIFIC NAME	SECTOR
WOOD DUCK	AIX SPONSA	8
TURKEY VULTURE	CATHARTES AURA	17, 18
MISSISSIPPI KITE	ICTINIA MISSIPPIENSIS	6, 9
RED-TAILED HAWK	BUTEO JAMAICENSIS	3, 5, 7, 11, 14, 19, 21
BROAD-WINGED HAWK	BUTEO PLATYPTERUS	6, 15
SPARROW HAWK	FALCO SPARVERIUS	7, 11, 12, 18
TURKEY	MELEAGRIS GALLOPAVO	6
BOBWHITE	COLINUS VIRGINIANUS	4, 5, 8, 10, 11, 13, 17-19
GREEN HERON	BUTORIDES VIRESCENS	4
AMERICAN BITTERN	BOTAURUS LINTIGINOSUS	7
KILLDEER	CHARADRUS VOCIFERUS	11, 12, 18, 19
SPOTTED SANDPIPER	ACTITIS MACULARIA	22
ROCK DOVE	COLUMBA LIVIA	12
MOURNING DOVE	ZENAIDURA MACROURA	4, 7-9, 12, 13, 17, 19, 21
CHUCK-WILL'S WIDOW	CAPRIMULEUS CAROUNENSIS	4, 5
CHIMNEY SWIFT	CHAETURA PELAGICA	8, 10, 13, 19

Appendix 1. Continued

COMMON NAME	SCIENTIFIC NAME	SECTOR
RUBY-THROATED HUMMINGBIRD	ARCHILOCHUS COLUBRIS	8, 13
YELLOW-SHAFTED FLICKER	COLAPTES AURATUS	1, 4-8, 10, 13, 14, 17-19
RED-BELLIED WOODPECKER	CENTURUS CAROLINUS	5, 8, 10, 13, 17-20
PILEATED WOODPECKER	DRYOCOPUS PILEATUS	4, 10, 13, 18, 19
RED-HEADED WOODPECKER	MELANERPES ERYTHROCEPHACUS	6, 8-10, 13, 14
DOWNY WOODPECKER	DENDROCOPOS PUBESCENS	8, 10, 18-20
EASTERN KINGBIRD	TYRANNUS TYRANNUS	8, 10, 13-15, 17-19, 21
GREAT CRESTED FLYCATCHER	MYIARCHUS CRINITUS	10
EASTERN WOOD PEWEE	COLTOPUS VIRENS	18
BARN SWALLOW	HIRUNDO RUSTICA	7, 12, 17, 18
ROUGH-WINGED SWALLOW	STELGIDOPTERYX RUFICOLLIS	18
PURPLE MARTIN	PROGNE SUBIS	7, 8, 18
BLUE JAY	CYANOCITIA CRISTATA	1, 5, 6, 8-10, 13-15, 17-19, 21-23
COMMON CROW	CORVUS BRANCHYRHYNCHOS	6, 18, 21
FISH CROW	CORVUS OSSIFRAGUS	13, 18
CAROLINA CHICKADEE	PARUS CAROLINENSIS	1, 4, 6-8, 10, 13, 18, 20
TUFTED TITMOUSE	PARUS BICOLOR	1, 6, 8, 10, 13, 17, 18, 20, 21, 23

Appendix 1. Continued

COMMON NAME	SCIENTIFIC NAME	SECTOR
RED-BREASTED NUTHATCH	SITTA CANADENSIS	1, 18
WINTER WREN	TROGLODYTES TROGLODYTES	4, 5, 10, 20
CAROLINA WREN	THRYOTHORUS LUDOVICIANUS	4-6, 8-10, 13, 17-19, 21
MOCKINGBIRD	MIMUS POLYGLOTTOS	4, 5, 8-10, 12-15, 17-19, 23
CATBIRD	DUMETELLA CAR LIHENSIS	4, 18
BROWN THRASHER	TOXISTOMA RUFUM	1, 4, 8-10, 19, 23
ROBIN	TURDUS MIGRATORIUS	13-15, 17
WOOD THRUSH	HYLOCICHLA MUSTELINA	4, 5, 9, 10, 13
SWAINSON'S THRUSH	HYLOCICHLA USTULATA	8
EASTERN BLUEBIRD	SIALIA SIALIS	6, 7, 9, 11, 13, 17-19, 21
STARLING	STURNUS VULGARIS	8, 12-15, 17, 19, 21
WHITE-EYED VIREO	VIREO GRISEUS	10
WARBLING VIREO	VIREO GILVUS	23
WORM-EATING WARBLER	HELMITHEROS VERMIVORUS	1
BLACK-THROATED GREEN WARBLER	DENDROICA VIRENS	1, 23
MYRTLE WARBLER	DENDROICA CORONATA	1, 8-10
CERULEAN WARBLER	DENDROICA CERULEA	8

Appendix 1. Continued

COMMON NAME	SCIENTIFIC NAME	SECTOR
WARBLER	AMERICANA	13
YELLOW THROAT	GEOTHLYPIS TRICHAS	4, 5
YELLOW-BREASTED CHAT	ICTERIA VIRENS	1, 5, 8, 17, 18, 23
EASTERN MEADOWLARK	STURNELLA MAGNA	3, 7, 8, 12-15, 17, 19, 21
RED-WINGED BLACKBIRD	AGELAIUS PHOENICEUS	5, 8, 17-19, 21
COMMON GRACKLE	QUISCALUS QUISCULA	10, 21
BROWN-HEADED COWBIRD	MOLOTHRUS ATER	7, 8, 10, 13, 15, 17
BALTIMORE ORIOLE	ICTERUS GALBULA	8, 10, 18, 23
SUMMER TANAGER	PIRANGA RUBRA	1, 6, 8, 10, 13, 17-19, 23
CARDINAL	RICHMONDENA CARDINALIS	1, 4, 6, 8, 10, 13-15, 19, 21
BLUE GROSBEAK	SUIRACA CAERULEA	3, 18
INDIGO BUNTING	PASSERINA C ANEA	4, 5, 13, 19, 21
PINE SISKIN	SPINUS PINUS	17
AMERICAN GOLDFINCH	SPINUS TRISTIS	4, 22
CHIPPING SPARROW	SPIZELLA PASSERINA	8, 18, 19
FIELD SPARROW	SPIZELLA PUSILLA	8
WHITE-THROATED SPARROW	ZONOTRICHIA ALBICOLLIS	4
HOUSE SPARROW	PASSER DOMESTICUS	17, 19

TABLE II

MAMMALS OBSERVED AT PINE BLUFF ARSENAL

COMMON NAME	SCIENTIFIC NAME
Opossum	Didelphis Marsupialis
Shorttail Shrew	Blarina brevicauda
Raccoon	Procyon lotor
STRIPED SKINK	Mephitis mephitis
Eastern Gray Squirrel	Sciurus canadensis
Eastern Fox Squirrel	Sciurus niger
Plains Pocket Gopher	Geomys bursarius
Fulvus Harvest Mouse	Reithrodontomys fulvescens
White-Footed Mouse	Peromyscus leucopus
Hispid Cotton Rat	Sigmodon hispidus
Eastern Cottontail	Sylvilagus floridanus
White-Tailed Deer	Odocoileus virginianus
Beaver[a]	Castor canadensis
Bobcat	Lynx rufus
Armadillo[a]	Dasypus novemcinctus

TABLE II continued

Coyote	*Canis latrans*
Muskrat	*Ondatra zibethica*
River Otter [c]	*Lutra canadensis*

[a]Sightings of tracks or nesting areas

[b]Sectors as in bird survey

[c]Observed during an aquatic survey May, 1976

Sector[b]
17, 18
20
6, 8, 13
18
13, 14
7, 9, 13-15, 17-20
14, 18
16
13, 10, 17, 18
5, 17, 18
8, 13, 15, 19-21
4, 5, 6, 8, 13-15, 20, 21
16, 18
14
16
13
15
16

TABLE III

RESULTS OF MAMMAL TRAPPING SURVEY. RATIO INDICATES CAPTURE PER NUMBER OF TRAPS SET

TRAPPING DATE

AREA	MAY 1	2	3	4	5	6	7	SEPTEMBER 18	19	20	21	
1	1/30	2/30										3
2	0/27	0/27	2/27									2
3-L		4/22	1/22	3/22	2/22							10
4			2/25	3/25								5
5-S				0/26	0/26	0/26						0
6					0/24	0/27	2/27					2
7								0/24	2/24			2
8-L									1/3			1
9-S									0/29	1/29	0/29	1
Totals	1/57	6/79	5/74	6/73	2/72	0/53	2/27	0/24	3/56	1/29	0/29	26/

TABLE IV

RESULTS OF THE TESTS OF SIGNIFICANCE BETWEEN SUCCESS RATES FOR THE DIFFERENT MAMMAL TRAPPING LOCALITIES

	AREA									
	8	3	4	1	7	6	2	9	5	To
Success	1	10	5	3	2	2	2	1	0	2
Failures	2	78	45	57	46	76	79	86	78	54
Total	3	88	50	60	48	78	81	87	78	57
% Trappings Success	0.333	0.110	0.100	0.050	0.042	0.026	0.025	0.011	0.000[a]	

[a]The line extends beneath those areas determined to be homogeneous.

Figure 4. Dendrogram of Bird Species at Pine Bluff Arsenal Based Upon Sectors

Figure 5. Dendrogram of Sectors at Pine Bluff Arsenal Based Upon Bird Species

TABLE V.

BIRD DATA REARRANGED IN DOUBLE DENDROGRAM ORDER

	1						2									3						
	17	19	8	10	13	18	4	5	9	1	6	23	14	15	21	7	12	11	3	22	20	
1 RED-TAILED HAWK	0	1	0	0	0	0	0	1	0	0	0	0	1	0	1	1	0	1	1	0	0	
30 RED-WINGED BLACKBIRD	1	1	3	0	0	3	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	
5 MOURNING DOVE	1	1	1	0	1	0	0	1	1	3	0	0	0	0	1	1	1	0	0	0	0	A
25 EASTERN BLUEBIRD	1	1	0	0	1	1	0	1	1	0	1	0	0	0	1	1	0	1	0	0	0	
35 INDIGO BUNTING	0	1	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	
16 COMMON CROW	0	0	0	0	0	3	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	
2 SPARROW HAWK	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	
4 KILLDEER	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	B
13 BARN SWALLOW	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	
14 PURPLE MARTIN	0	0	3	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	
6 CHIMNEY SWIFT	0	1	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
9 PILEATED WOODPECKER	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C
3 BOBWHITE	3	3	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	
8 RED-BELLIED WOODPECKER	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	

TABLE V. Continued

		1						2									3						
		17	19	8	10	13	18	4	5	9	1	6	23	14	15	21	7	12	11	3	22	20	
11	DOWNEY WOODPECKER	0	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
36	CHIPPING SPARROW	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
28	YELLOW-BREASTED CHAT	1	0	1	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	C
32	BALTIMORE ORIOLE	0	0	1	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	
12	EASTERN KINGBIRD	1	1	3	1	1	1	0	1	0	0	0	0	1	1	1	0	0	0	0	0	0	
34	CARDINAL	0	1	1	1	1	0	0	1	0	1	1	0	1	1	1	0	0	0	0	0	0	
7	YELLOW-SHAFTED FLICKER	1	1	1	1	1	1	0	0	0	1	1	0	1	0	0	1	0	0	0	0	0	
20	CAROLINA WREN	1	1	1	1	1	1	0	1	1	0	1	0	0	0	1	0	0	0	0	0	0	
15	BLUE JAY	1	1	1	1	1	1	0	3	1	1	1	3	1	1	3	0	0	0	0	1	0	
21	MOCKINGBIRD	1	1	1	1	1	1	0	0	1	0	0	1	1	1	0	0	1	0	0	0	0	D
1	TUFTED TITMOUSE	1	0	1	1	1	1	1	1	0	1	1	1	0	0	1	0	0	0	0	0	1	
33	SUMMER TANAGER	1	1	1	1	1	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	
17	CAROLINA CHICKADEE	0	0	1	1	1	1	1	0	0	1	1	0	0	0	0	1	0	0	0	0	0	
10	RED-HEADED WOODPECKER	0	0	1	1	1	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	
22	BROWN THRASHER	0	1	1	1	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	

TABLE V. Continued

		1						2										3						
		17	19	8	10	13	18	4	5	9	1	6	23	14	15	21	7	12	11	3	22	20	
27	MYRTLE WARBLER	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	
19	WINTER WREN	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	D
24	WOOD THRUSH	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	
26	STARLING	3	3	1	0	1	0	0	1	0	0	0	0	1	1	1	0	3	0	0	0	1	
29	EASTERN MEADOWLARK	1	1	1	0	1	0	0	1	0	0	0	0	1	1	1	1	1	0	1	0	1	E
23	ROBIN	1	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	
31	BROWN-HEADED COWBIRD	3	0	1	1	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	

TABLE VI.

RESULTS OF TESTS OF SIGNIFICANCE BETWEEN THE MULTIPLE MEANS OF THE SUB-DIVISIONS IN THE REARRANGED BIRD DATA

Subdivisions	Means	Regions of Homogeneity of Means
2B	.0000	
3D	.0595	
3C	.0625	
2C	.0694	
3A	.1944	
2E	.3056	
3B	.3333	
2A	.3704	
1B	.3750	
3E	.3750	
2D	.4524	
1A	.6111	
1D	.7381	
1C	.8125	
1E	.8333	

TABLE VII.

THE RELATIONSHIP BETWEEN THE SUBDIVISIONS OF THE REARRANGED BIRD DATA

Clusters of Sectors			
1	2	3	Clusters of Species
High	Low	Low	A
?	Low	Low	B
High	Low	Low	C
High	High	Low	D
High	Low	?	E

TABLE VIII.

"'PHIBANS AND REPTILES OBSERVED AT PINE BLUFF ARSENAL

	SCIENTIFIC NAME	COMMON NAME	SECTOR
11	Coluber Constrictor Priapus	SOUTHERN BLACK RACER	18
3	Terrapene Carolina Triunguis	THREE-TOED BOX TURTLE	4,8,18.20
4	Pseudemys Scripta Elegans	RED-EARED TURTLE	8,15,17,18,23
1	Chelydra Serpentina Serpentina	COMMON SNAPPING TURTLE	8,14
22	Rana Clamitans Melanota	GREEN FROG	4,5,8,10,18,21,
12	Opheodrys Aestivus	ROUGH GREEN SNAKE	19
9	Natrix Rhombifera Rhombifera	DIAMOND-BACKED WATER SNAKE	18
16	Siren Intermedia	LESSER SIREN	4, 18
	Agkistrodon Contortrix Contortrix	SOUTHERN COPPERHEAD	7, 18
19	Acris Crepitans	CRICKET FROG	4,5,8,12,18,19
2	Kinosternon Subrubrum Hippocrepis	MISSISSIPPI MUD TURTLE	19
18	Bufo Woodhousei Fowleri	FOWLER'S TOAD	1,5,8,13,18
17	Bufo Americanus Charlesmithii	DWARF AMERICAN TOAD	10,13,20
20	Gastrophyrne Carolinensis	EASTERN NARROW-MOUTHED TOAD	10,21
7	Lygosoma Laternale	GROUND SKINK	10,20
23	Rana Pipens Sphenocephela	SOUTHERN LEOPARD FROG	8,18
21	Rana Catesbiana	BULLFROG	17,18
15	Agkistrodon Piscivorus Leucostoma	WESTERN COTTONMOUTH	13,18
8	Ophisaurus Attenuatus Attenuatus	WESTERN SLENDER GLASS LIZARD	18

TABLE VIII. (Continued)

	SCIENTIFIC NAME	COMMON NAME	SECTOR
5	Sceloporus Undulatus Hyacinthinus	NORTHERN FENCE LIZARD	1,6,7,1
14	Crotalus Horridus Atricaudatus	CANEBRAKE RATTLESNAKE	10
6	Cnemidophorus Sexlineatus	SIX-LINED RACERUNNER	5,10
10	Thamnophis Sauritus Proximus	WESTERN RIBBON SNAKE	13

TABLE IX.

PLANTS OBSERVED AT PINE BLUFF ARSENAL

Scientific Name	Family	Common Name	Area
Acalypha setosa	Euphorbiaceae		7
Acalypha sp.	"		6
Acer rubrum L.	Aceraceae	Red Maple	1,3
Aesculus pavia L.	Hippocastinaceae	Red Buckeye	9
Agrostis hyemalis (Walt.) BSP	Gramineae		4
A. perennans (Walt.) Tuckerm.	"		2
Ambrosia bidentata Michx.	Compositae	Ragweed	2,7
A. rugelii	"	"	7
Ampelopsis arborea (L) Koehne	Vitaceae	Pepper Vine	6,8
Cenchrus tribuloides	Gramineae	Sand-bar Grass	7
Andropogon gerardi	Vitm.	Turkeyfoot or Big Bluestem	7,9
A. scoparius Michx.	"	Little Bluestem	1,5
A. ternarius Michx.	"	Silver Beardgrass	7
Aralia spinosa L.	Araliaceae	Hercule's Club	5

.E IX. Continued

Scientific Name	Family	Common Name	Area
Aristida dichotoma Michx.	Gramineae	Poverty Grass	7,10
Ascyrum hypericoides L.	Hypericaceae	St. Andrew's Cross	2,5
Aster lateriflorus (L) Britt.	Compositae	Aster	4
A. patens Ait.	"	"	2,3
Azolla caroliniana Willd.	Salviniaceae	Water Velvet	4
Baccharis halmifolia L.	Compositae	Groundsel-tree	1
Berchemia scandens (Hill) Trel.	Rhamnaceae	Supple-jack	4,6
Betula lutea Michx. var. macrolepis Fern.	Corylaceae	Yellow or Gray Birch	3
Bidens aristosa (Michx.) Britt.	Compositae	Beggar's Ticks	4
B. Polylepis Blake	"	" "	5
Boehmeria cylindrica (L) Sw.	Urticaceae	False Nettle	4,6,7
Cardiospernum halicacabum L.	Sapindaceae	Heart Seed	4
Callicarpa americana L.	Verbenaceae	French Muhlberry	8
Carya illinoensis (Wang) K. Koch	Juglandaceae	Pecan	3,5,8
C. texana Buckl.	"		9
Campsis radicans (L) Sam.	Bignoniaceae	Trumpet Creeper	8

TABLE IX. Continued

Scientific Name	Family	Common Name	Area
carya tomentosa Nutt.	Juglandaceae	Mockernut Hickory	2,9
cassia fasciculata Michx.	Leguminosae	Partridge Pea	2,8
C. *marilandica* L.	"		5
castanea pumila (t) Mill.	Fagaceae	Chinquapin	2
celtis laevigata Willd.	Ulmaceae	Hackberry	6,8,10
cephalanthus occidentalis L.	Rubiaceae	Buttonbush	4,9
cocculus carolinus (L) DC	Menispermaceae	Red berried Moonseed	4
conyza canadensis			8
Cornus florida L.	Cornaceae	Flowering Dogwood	1-3,6
C. racemosa Lam.	"	Gray Dogwood	8
Crataegus sp.	Rosaceae	Hawthorn	6
Croton capitatus Michx.	Euphorbiaceae	Hogwort	1,7
Cynodon dactylon (L) Pers.	Gramineae	Bermuda Grass	7,8,10
Cyperus erythrorhiza Muhl.	Cyperaceae		4
C. strigosus L.	"		4
Digitaria ischaemum (Schreb.) Muhl.	Gramineae	Smooth Crabgrass	4,10
D. sanguinalis (L) Scop.	"	Crabgrass	8,10

TABI X. Continued

Scientific Name	Family	Common Name	Area
Diodia teres Walt.	Rubiaceae	Buttonweed	2,4,7
D. virginiana L.	"	Buttonweed	6,7,9
Diospyros virginiana L.	Ebenaceae	Persimmon	1,2
Eclipta alba (L) Hassk.	Compositae	Yerba-de-Tago	4
Eleocharis tenuis (Willd) Schultes	Cyperaceae	Slendor Spikerush	6
Elymus virginicus L.	Gramineae	Wild Rye	2
Eragostis spectabilis (Pursh) Steud.	Gramineae	Tumble Grass	1,7
Erechtites hieracifolia (L) Raf.	Compositae	Fireweed	1
Erianthus alopecuroides (L) Ell	Gramineae	Woolly Beardgrass	4
Erianthus sp.	"		1
Eupatorium coelestinum L.	Compositae		4
E. perfoliatum L.	"	Boneset	2,4-7
E. rotundifolium L.	"		4
Euphorbia maculata L.	Euphorbiaceae	Wartweed	7,8
E. corollata L.	"		2
Fraxinus lanceolata Borkh.	Oleaceae	Green Ash	5,6,8,10

TABLE IX. Continued

Scientific Name	Family	Common Name	Area
Froelichea floridana (Nuttall) Moq.	Nyctaginaceae	Cottonweed	8
Gerardia purpurea L.	Scrophulariaceae	Purple Gerardia	1,5,7
G. tenuifolia Vahl.	"		5,8
Mollugo verticillata L.	Aizoaceae	Carpetweed	8
Monarda punctata L.	Labiatae	Horsemint	8
Morus rubra L.	Moraceae	Red Mulberry	4
Myrica cerifera L.	Myricaceae	Wax Myrtle	1
Nelumbo lutea (Willd) Pers.	Nymphaceae	Yellow Lotus	4
Nyssa aquatica L.	Nyssaceae	Water (Cotton) Gum	10
N. sylvatica Marsh.	"	Sour Gum or Tupelo	2,3
Panicum agrostoides Spreng.	Gramineae	Panic Grass	4,5
P. depauperatum Muhl.	"	" "	5,8
P. dichotomoflorum Michx.	"	" "	5
P. microcarpon Muhl.	"	" "	5,6
P. villosissimum Nash	"	" "	1,3
Parthenocissus quinquefolia (L) Planch	Vitaceae	Virginia Creeper	4

TABLE IX. Continued

Scientific Name	Family	Common Name	Area
Paspalum ciliatifolium Michx.	Gramineae	Paspalum Grass	5,7
P. dilatatum Poir.	"	" "	7,10
P. urvillei Steud.	"	" "	8
Passiflora lutea L.	Passifloraceae	Passion Flower	2
Persea borbonia (L) Spreng.	Lauraceae	Red-Bay	2
Pilea pumila (L) Gray	Urticaceae	Richweed	7
Pinus echinata Mill.	Pinaceae	Short-leaf Pine	2,9
P. taeda L.	"	Loblolly Pine	1-3,5
Plantago rugelii Dcne.	Plantaginaceae	Rugel's Plantain	7
Polygonum hydropiper L.	Polygonaceae	Water Pepper	4
P. hydropiperoides Michx.	"	Mild Water Pepper	4
P. pensylvanicum L.	"	Pennsylvania Knotweed	4
Populus deltoides Marsh.	Salicaceae	Northern Cottonwood	7
Prunus serotina Ehrh.	Rosaceae	Black or Rum	5,7-10
Pteridium aquilinum (L) Kuhn	Polypodiaceae	Bracken Fern	1,2
Quercus alba L.	Fagaceae	White Oak	2,3
Q. *falcata* Michx	"	Southern Red Oak	1-3

TABLE .. Continued

Scientific Name	Family	Common Name	Area
Quercus palustris Muenchh	"	Pin Oak	10
Q. Phellos L.	"	Willow Oak	1,3
Q. shumardii Buckl.	"	Shumard's Red Oak	10
Q. stellata Wang.	"	Post Oak	1-3
Q. velutina Lam.	"	Black Oak	2
Rhexia virginica L.	Melastomataceae	Deer Beauty	4
Rhus copallinum L.	Anacardiaceae	Dwarf Sumac	2,3,5
Rhus toxicodendron L.	"	Poison Ivy	6
Rhyrehaspora sp.	Cyperaceae	Beak Rush	1
Salix. nigra L.	Salicaceae	Black Willow	4,7
Sambucus caradensis L.	Caprifoliaceae	Common Elder	5
Sassafras albida (Nutt)	Lauraceae	Sassafras	1
Sourarus cernus L.	Saururaceae	Lizard's Tail	4
Scirpus sp.	Cyperaceae	Bull Rush	1
Smilax rotundifolia L.	Liliaceae	Bull Briar.	6
Smilax glauca Walt.	"	Catbriar	1,5

TAP IX. Continued

Scientific Name	Family	Common Name	Area
	"	Common Green Briar	1
Solidago altissima Ait.	Compositae	Goldenrod	7,8
S. odora Sit.	"	Sweet Goldenrod	1-3
	"	Goldenrod	8
	"	"	2,3
	"	"	2
	Gramineae	Johnson Grass	4,8
	Lamnaceae	Duckweed	4
	Gramineae	Poverty Grass	7
	Leguminosae	Wild Bean	2,7-10
Taxodium distichum (L) Richard	Pinaceae	Bald Cypress	4
Trachelospernum difforme (Walt) Gray	Apocynaceae	Climbing Dogbane	4
Trifolium repens L.	Leguminosae	White Clover	4
Ulmul alata Michx.	Ulmaceae	Winged Elm	4-6
Uniola laxa (L) BSP	Gramineae		1,2
Vaccinium arboreum Marsh	Ericaceae	Farkleberry	1,2

TABLE IX. Continued

Scientific Name	Family	Common Name	Area
Verbena cf. *encelioides* (Cav.) B & H	Compositae		4
Veronia peregrina L.	Compositae	Ironweed	4
Vitis aestivalis Michx.	Vitaceae	Summer Grape	2,4
V. rotundifolia Michx.	"	Muscadine Grape	1-4
Woodwardia areolata (L) Moore	Polypodiaceae	Netted Chain Fern	1
Xanthium strumarium L.	Compositae	Cocklebur	7

Locations of plant survey areas shown in Fig. 3. Area 10 refers to partly cultivated and roadside.

Discussion

The surveys described in this report detected a number of areas with disturbed vegetation. Prompted by our initial findings we investigated further and found that some were contaminated with various manufacturing wastes. Although the locations of all these areas were not known at the time the survey sectors were selected, it now seems prudent to analyze the data using the additional information.

Sector 12, the abandoned North Production Area, was used as a manufacturing area for mustard-filled munitions, lewisite, DDT, chlorine, and sulfuric acid. The surfaces of the buildings are so contaminated with mustard agent that they cannot be safely dismantled. Open dumps of waste DDT in this area are constantly eroded by surface runoff, and hence the receiving tributaries are also heavily contaminated. Arsenic is potentially present from the past production of lewisite.

Sector 8, containing the toxic gas storage yard, is a good example of a largely undisturbed sector. However; a fraction of Sector 8, just south of the storage yard is severly damaged. This function consists of a borrow pit (where fill dirt was excavated) which was used for the disposal of mustard. During the disposal procedure, decontamination material was disced into the soil, which is now so damaged that invading weeds are unable to colonize the area.

Sector 10 includes a munitions test area and is reported to be contaminated with Chloroactophenone (CN), a tear agent, Adamsite (DM), a vomiting agent, pyrotechnics, munitions, smokes and incendiaries (T. Shook, oral communication). The area surrounding Yellow Lake (sector 18), its feeding tributaries, and the lake itself are contaminated with elemental phosphorous, DDT, pyrotechnics and munitions.[9]

A. Mammals

Nothing in the data on mammals sighted indicates a generally adverse effect of PBA activities. The trap site with a success rate which was significantly lower than the site with the highest rate was in an area known to be free of disturbances. The rodent populations were low compared with similar populations elsewhere [10,11] while potential predators (at least six species of predatory mammals, four species of birds of prey, and four species of predatory snakes) were relatively common. Whether the mammal population was at a low in a cyclic pattern[12] or a balance had been reached between the food source, cover and predator pressure could not be determined.

B. Birds

Bird population exhibited no adverse effects from the activities at PBA. There were both numerous species and individuals. The result of the dendrogram analysis does not follow the control versus experimental sectors described in the Materials and Methods section. Rather, in retrospect, it closely follows the sectors where most of the time was spent: Sectors in category 1 were visited most frequently, those in category 2 were visited less frequently and those in category 3 were visited least frequently. In this regard sectors 2 and 16 which were not clustered and because of insufficient data they were not studied at all. The only exception was area 12 which was heavily contaminated (see above) and was studied intensely. All other sectors apparently had sufficiently diverse habitats and healthy populations so that adverse effects, if any, were masked.

C. Amphibians and Reptiles

Amphibians and reptiles were well represented, and apparently showed no widespread adverse effect. Nor was there significantly fewer species of amphibians in the experimental areas. In a few limited pond and stream locations in sectors

12 and 13 amphibians and aquatic invertebrates were absent. The pH conditions were unacceptable to sustain life.[2]

D. Conclusions

Most of the land areas of PBA appear to be environmentally healthy on a gross scale. However certain sections, the largest of which occurs in sector 12, are severly contaminated with decontamination products, munitions wastes, and pesticides remaining from the ~~sloppy~~ manufacturing and disposal techniques of the past. Each rainfall erodes more of these contaminants into the surrounding streams thus spreading the effects through the environment. Therefore the major impact of these relatively limited sources of terrestrial disturbances are found in studies of aquatic systems. The terrestrial impacts of the installation activities should be studied in detail at specific problem areas identified in this report. ~~It appears that~~ The studies should include soil invertebrates and bioaccumulation of pesticides, heavy metals, and elemental phosphorous in some of the common vertebrates.

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APPENDIX G

USA ENGINEER WATERWAYS EXPERIMENT STATION

LITERATURE SURVEY ON SURFACE AND SUBSURFACE CHARACTERISTICS

AT PINE BLUFF ARSENAL

FEBRUARY 1976

I. E. 3.

A LITERATURE SURVEY ON SURFACE AND SUBSURFACE CHARATERISTICS AT PINE BLUFF ARSENAL, ARKANSAS

by

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February 1976

Draft Report

Prepared for U. S. Army, Pine Bluff Arsenal
Pine Bluff, Arkansas 71601

SUMMARY

Personnel of the Waterways Experiment Station (WES) visited or contacted eleven Federal or State organizations to collect data relevant to the hydrogeological regime of a north-central portion of the Pine Bluff Arsenal (PBA). Attention was focused on collecting and reviewing topography, soils, geology, and hydrology information.

These data were examined and, where necessary, translated to formats which were more applicable to the hydrogeologic descriptions. Data are discussed and presented as tables, figures, and plates illustrating surface soils, subsurface soils, slope, permeability, landforms, drainage, piezometric surfaces, and precipitation.

According to the data collected and extrapolated, the PBA ranges in elevation from 200 to 300 ft mean sea level (msl) and is underlain, in part, by a piezometric surface approximating 190 to 195 ft msl. The gently sloping surfaces are predominantly silts with infiltration being retarded by hardpans in the shallow subsurface. The precipitation is approximately 50 in. with an excess of potential evaporation.

Based upon available data and program requirements, a detailed plan of sampling and analysis was included.

PRELIMINARY

PREFACE

The study reported on herein is a portion of the Pine Bluff Arsenal (PBA) Engineering and Technology Directorate's program to assess the potential groundwater pollution by past or ongoing activities of the Arsenal. The study is an initial phase of a more complete program described in Appendix A; authority to conduct this study was given by PBA to the Waterways Experiment Station (WES) by teletype dated 3 November 1975, subject: "FJ6 P1856FJQ6."

The study was conducted during the period of November 1975 to January 1976 by personnel of the Engineering Geology and Rock Mechanics Division (EGRMD), Soils and Pavements Laboratory (S&PL). The study aims and approach were reviewed by personnel of the Mobility and Environmental Systems and Environmental Effects Laboratories prior to execution. Mr. Jerald D. Broughton was responsible for the conduct of the study and preparation of this report. He was assisted by Messrs. Harry K. Woods, Donnie E. Andrews, and Mrs. Marilyn B. Worthy. All portions of the work were under the direct supervision of Mr. John H. Shamburger, Chief, Terrestrial Sciences Branch, and under the general supervision of Mr. Don C. Banks, Chief, EGRMD, and Messrs. James P. Sale and Richard G. Ahlvin, Chief and Assistant Chief, respectively, of the S&PL.

Director of the WES during the conduct of this study and preparation of this report was COL G. H. Hilt, and Technical Director was Mr. F. R. Brown.

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CONVERSION FACTORS, BRITISH TO METRIC UNITS OF MEASUREMENT

The following table is given so that units used in this report can be converted from British to metric equivalents.

Multiply	By	To Obtain
inches	2.54	centimeters
feet	0.3048	meters
miles	1.609344	kilometers
acres	0.4047	hectares
in./hr	0.000706	cm/sec
in./year	2.54	cm/year

PRELIMINARY

A LITERATURE SURVEY ON SURFACE AND SUBSURFACE CHARACTERISTICS AT PINE BLUFF ARSENAL, ARKANSAS

PART I: INTRODUCTION

Background

1. The PBA has been in operation for over 30 years; during that time the Army as well as private firms under lease agreements have manufactured substances that have been handled, stored, or discarded in such a manner that potential pollution problems exist in the surface water and groundwater at the PBA. Recent observations and studies at the Rocky Mountain Arsenal have provided an insight to the magnitude of potential contaminant problems associated with these types of operations. Studies, starting in 1966 and continuing to the present, have been made by the PBA, Edgewood Arsenal (EA), the U. S. Army Environmental Hygiene Agency (AEHA), and WES to examine different portions of the potential problem. Advice and guidance for continuing studies are currently given by the Chemical Demilitarization and Installation Restoration group of the Army Materiel Command.

2. The PBA has determined that several areas of the installation are, or have been, subject to surface accumulation of materials which are potential sources of contamination. The studies to date have provided a definitive understanding of contaminant problems associated with surface waters and have led to planned actions to treat this aspect of the problem. To date, however, little or no understanding exists for evaluating the potential contamination of groundwater at the PBA.

3. The WES was requested to make a hydrogeological site assessment of one area (consisting of two sites) at the PBA. The assessment will be completed in FY 1977 and will result in the site description and determination of parameters required to determine the present extent of any groundwater pollution as well as to anticipate or predict future trends. The study reported herein is the initial phase of the assessment; specifically, data relating to subsurface conditions (and surface

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conditions, as relevant) were collected and examined to determine the extent and details of available information and to enable firm plans to be made for the remaining phases of the hydrogeological study.

Purpose and Scope

Purpose

4. The purpose of this study is to determine sources of information pertaining to the subsurface (and the surface, as relative), to collect available data and to evaluate the information as it pertains to a hydrogeological description and parameters necessary to make a hydrogeological study of a specified disposal area at PBA (see Figure 1). This information will assist in recommending a plan of action to generate required hydrogeological data for the study area in the future.

Scope

5. This study is concerned with some 65 acres located in the north-central portion of the PBA as shown on the topographic map[1*] (Figure 1). While attention was focused on this area during data collection and evaluation, the search for data and subsequent development of a recommended plan of action, required collection and evaluation of information covering the entire reservation, Jefferson County, Arkansas, and/or the south-central United States for background purposes.

6. Inquiries were made to both Federal and State agencies as well as applicable military installations to secure information required for the study. All maps were prepared without the benefit of any on-site field data collection.

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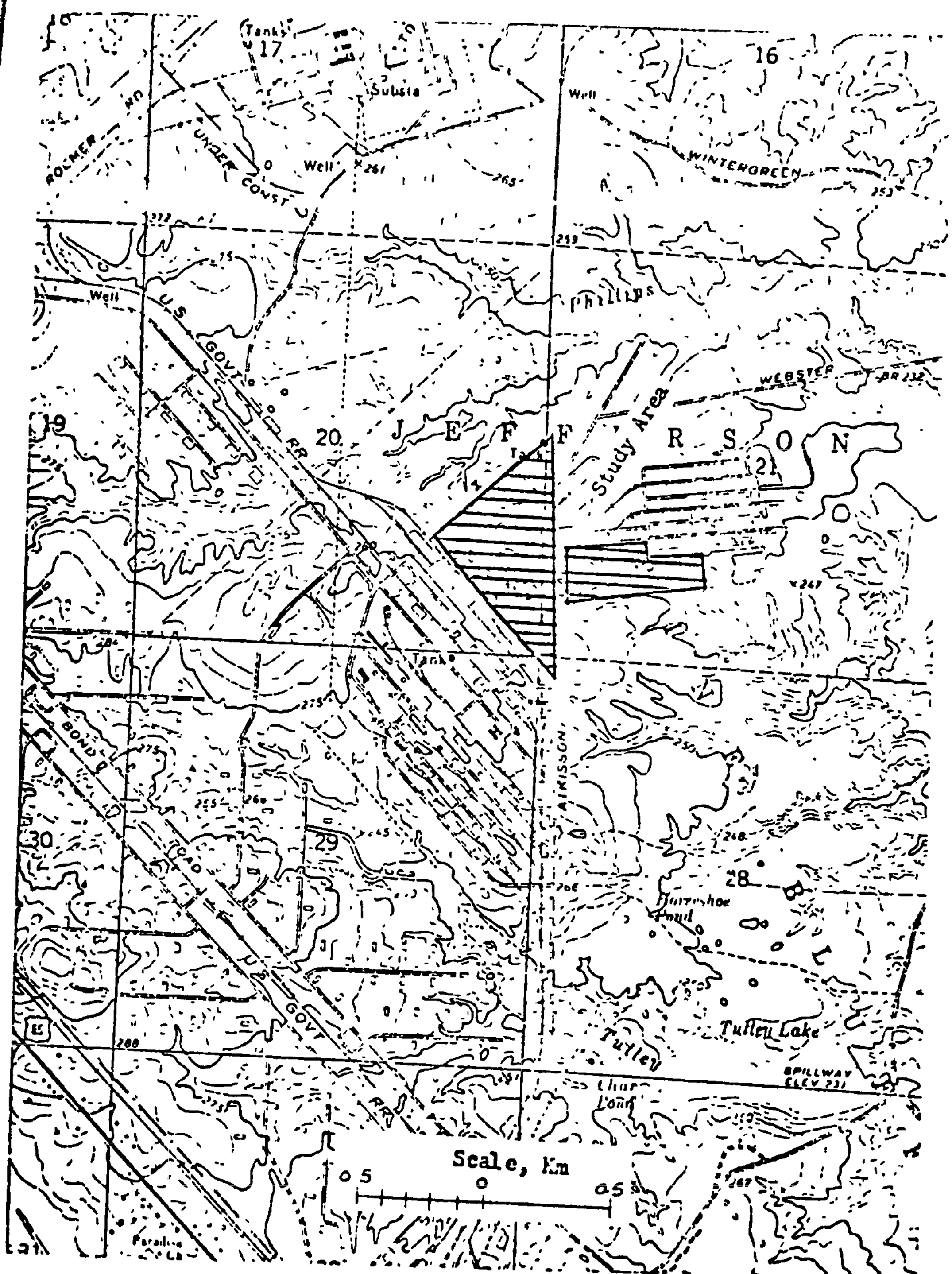
* Raised number indicates entries similarly numbered in Reference list.



1 Portion of 1:24000 Topographic Map Showing Study Area

PART II: LITERATURE SURVEY

Approach

7. Since a wide spectrum of data exists, to make the study meaningful to a hydrogeologic assessment, those factors that cause or influence movement of contaminants on the surface or through the subsurface from its present disposal location were determined. Those factors were considered to be:

- a. Soil type (surface and subsurface)
- b. Landforms
- c. Topographic slope
- d. Surface and subsurface drainage (permeability)
- e. Rainfall (amount, intensity, and frequency)
- f. Groundwater conditions (depth and thickness)
- g. Depth to bedrock

Data search

8. The search at WES for data pertaining to the above factors consisted of obtaining a computerized data listing from the Defense Documentation Center and reviewing reference material in the files of the Engineering Geology and Rock Mechanics Division and the Technical Information Center. In addition, the following agencies were contacted to determine the availability of information in their files that would be applicable to the study.

- a. U. S. Army Engineer District, Little Rock
- b. U. S. Army Engineer District, Fort Worth
- c. U. S. Geological Survey, Little Rock
- d. U. S. Department of Agriculture, Little Rock
- e. Arkansas Geological Commission
- f. U. S. Army Engineer District, Vicksburg
- g. U. S. Army Engineer Division, Southwest
- h. U. S. Army Environmental Hygiene Agency, Aberdeen Proving Ground

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i. Edgewood Arsenal, Aberdeen Proving Ground

j. Southeast Arkansas Planning Commission, Pine Bluff, Arkansas

k. U. S. Soil Conservation Service, Monticello, Arkansas

9. Discussions were held at PBA with members of the Facilities Directorate to familiarize WES personnel with prior and ongoing studies that might contribute to the current project and a limited reconnaissance of the study area was conducted.

10. State and Federal offices in Little Rock, Arkansas (listed above) and the U. S. Army Engineer District, Fort Worth, Texas, were visited to review and collect information.

Types of Data

11. Personnel of the above named agencies contributed a substantial amount of information consisting of textbooks, regional reports, state surveys, county studies, and several items relating solely to the PBA. The detail of the information varied from exact chemical analysis of soil samples from within the study area to the general, historical accounts of the Mississippi embayment.

12. Descriptions of general environmental conditions of the PBA and Jefferson County were available and of reasonable detail. The soils of the PBA were described by the U. S. Department of Agriculture draft reports and portrayed on large scale (1:15,840) aerial photographs. The soils are described from the surface to an approximate depth of 6 ft.

13. Useful subsurface information on the PBA was limited. Numerous foundation borings have been drilled but depths are usually less than 20 ft. Several of these borings penetrated a saturated zone but the free water was attributed to a perched water table. Numerous shallow borings have been made to obtain samples from the study area for chemical analysis; all samples have been crushed which prohibited any future engineering test. No descriptive accounts of the strata were maintained and retrieval of any information relative to grain size, permeability, or stratification is impossible. Driller's logs (generalized descriptions) were located for two monitoring wells drilled in the vicinity of the study area; no physical test were performed on any of the samples.

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14. Climatic data were available in forms of long-term average precipitation records, evaporative maps, and small scale rainfall maps. Precipitation amounts and distributions were available.

Data review

15. The data collected during this study were cursorily reviewed in the order received. This brief review indicated the factor(s) described and their potential usefulness. If the data source contained pertinent information, a bibliographic entry was made and a brief notation made concerning subject matter and scope of investigation. The review was a continuing process requiring a re-review of previously obtained references to check on agreement between different sources of information.

16. Upon receipt of available reference material (approximately 80 items), they were placed into groups that related to surface, subsurface, and climatic conditions. Information in each group was then examined to determine which could contribute to the required site descriptions. An attempt was made to select those which covered, in order of priority, the study area, the PBA, Jefferson County, the State of Arkansas, and the Arkansas River Valley.

17. Material specifically covering the study site was extremely limited and most studies more broadly addressed PBA or Jefferson County. From these broader studies, the portion of data applicable to the area of interest, either the study area or the PBA was extracted and utilized to prepare the data as presented in Part III, Site Description.

18. The reference material identified during the study are presented in two sections--Reference and Bibliography. The Reference Section lists those reports that were used as direct input to the site description. The Bibliography Section lists literature that was identified during the study but not used directly to describe the site. During the study period, approximately fifty percent of these entries were received and inspected.

PART III: SITE DESCRIPTION

19. While the study concerns the specific area shown on Figure 1, little data were found that pertained exclusively to that area. As a result, the data extracted from the references were used to describe the PBA in terms of the pertinent factors with conclusions given, where possible, as to how these factors influenced the hydrogeology description for the specific site (Figure 1). In most cases, data were available from one or more sources. The data were supplemented by interpretations of aerial photographs of PBA. The descriptions are divided into three categories--surface, subsurface, and rainfall characteristics and each category is described in narrative and graphic form.

Surface Characteristics

20. Landforms within the PBA can be divided into three units, (a) uplands, (b) alluvial terrace, and (c) alluvial plain. The uplands are Tertiary (Jackson group) deposits consisting of unconsolidated sediments (predominantly silts and sandy silts)[2,3,4,5] and are characterized by a level to gently rolling surface interrupted by drainage ways of varying sizes. The uplands are bordered by the alluvial terrace and, in some places, by the alluvial plain. The demarcation between the alluvial terrace and the uplands cannot be made on the basis of topography alone—rather, soil types must be relied upon for separating the two. In contrast, an abrupt slope usually forms the boundary between the alluvial terrace and the alluvial plain. Topographically the surface of the alluvial terrace is similar to the uplands in that it is level to gently rolling and is interrupted by streams of varying sizes. The surface of the alluvial terrace is composed of alluvial silts, sandy silts, and clays except in the southern part of PBA where these soils are veneered by loess deposits (aeolian silts). A well defined scarp forms the boundary between the alluvial terrace and the lower lying alluvial plain. The alluvial plain is a relatively flat floodplain

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of the Arkansas River and its tributaries. This surface is characterized by meander belt deposits consisting of abandoned channels, natural levee, backswamp, and point-bar deposits. The surface soils range from clays, silts, to silty sands depending upon the environment of deposition. The landforms are graphically portrayed in Figure 2 and the occurrence of surface soil types are shown on Plate 1.

21. As shown in Figure 2, the boundary between the uplands and the alluvial terrace, almost bisects the site. However, while Plate 1 shows the surface soils at the site to consist of low plasticity silts (ML*) and silty sands (SM*), silty sands predominate suggesting that the surface is free of a loess veneer. It should be re-emphasized here that the data from which these conclusions are reached result from generalized data obtained from the literature and not from on-site sampling and required laboratory testing and classification. The inferrence is that rainwater is relatively free to infiltrate through the surface soils at the study site. This free draining state is highly modified by the existence of hardpans over much of the PBA.

22. Slopes are very gentle over most of the PBA. In many places, they are less than one percent and seldom exceed three percent.[2] Slopes of the escarpment between the uplands and the alluvial plain are greater than 100 percent, but the aerial extent is limited. Slopes bordering the drainage ways sometimes approach or exceed 12 percent, but again, these are of limited areal extent. Surface drainage is well developed and nearly all areas of the developed portions of the PBA are well drained. Slopes generally associated with specific soil types[2] (as shown on Plate 1) provided the basis for the slope map shown on Plate 2. Examination of topographic maps[1] generally confirm the slopes as presented. Ravines and stream channels usually produce slopes greater than those shown on Plate 2 necessitating further treatment on a final, large-scale project map. As shown on Plate 2 the eastern part of the site should have slopes ranging from 1 to 3 percent; the western part of the site

* Designations from United Soil Classification System

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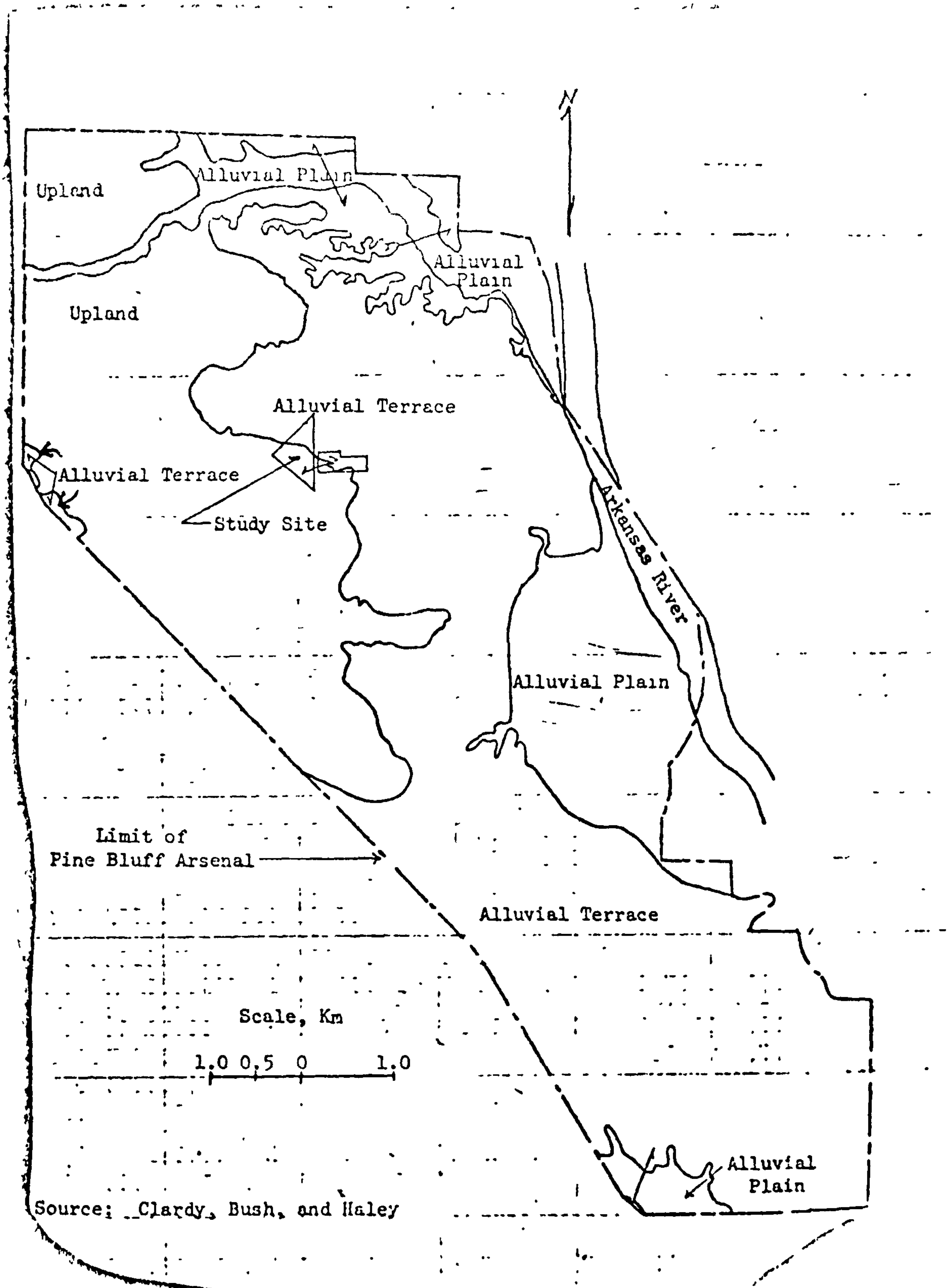

Pine Bluff Arsenal Landforms

should have slopes ranging from 3 to 8 percent. Such information is important to site assessment in that the slope indicates whether rainfall would tend to leave the area as surface runoff (steep slopes) or infiltrate (shallow slopes). However, the study indicated that drainage of the uplands and the alluvial terrace at PBA is principally in the form of surface runoff and not infiltration.

23. The lower lying alluvial plain is frequently flooded and is characterized by an extremely shallow water table. The alluvial terrace and uplands surfaces are drained by a series of permanent and ephemeral streams and drainage ways. For example, in a general review, VTN Louisiana, Inc.[6] considered the entire PBA as belonging to the Arkansas River Basin drainage system. In a more detailed study, an Edgewood Arsenal report subdivided the PBA into eight sub-basins of drainage. Figure 3 shows the surface drainage in the vicinity of the study area. Precipitation on the study area constributes runoff to two of the eight sub-basins which are drained by Triplett and Tulley Creeks. CALLED PHILIPPS CREEK IN FIG 1

24. Land use affects surface runoff and infiltration. An examination of data for the entire PBA shows the usual land uses associated with a reservation of this type, i.e. production areas, storage areas, recreational areas, woodlands, etc., but the immediate site is in an abandoned state with no organized use. For this reason no land use map was prepared.

Subsurface Characteristics

25. The subsurface characteristics are discussed in terms of soil types, permeability, and groundwater conditions. The referenced data on soil types and permeability dealt only with materials found in the top 6 ft of the subsurface; no data exists for deeper materials.

26. The subsurface soils of the uplands are similar to the surface soils in that they are predominantly silts, but with increasing amounts of clay with depth. The subsurface soils of the alluvial terraces

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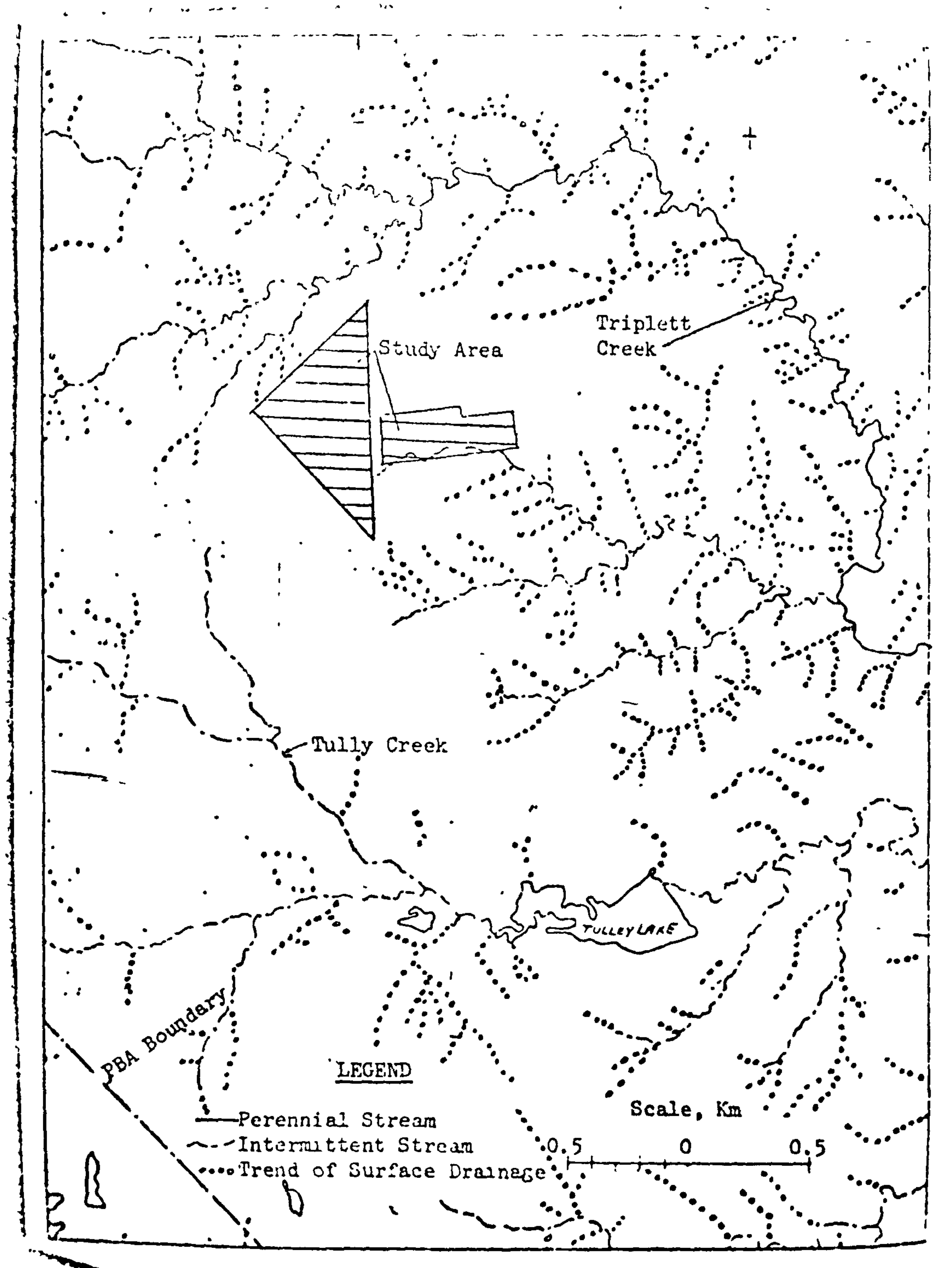

Pine Bluff Arsenal Study Area and Vicinity Surface Drainage are predominantly silts and clays for varying depths and are underlain by coarser material. The depth to and type of material underlying the alluvial plain depends upon the environment of deposition. Practically all types of material (sand, clay, silt, and gravels) can be encountered at some depth in the subsurface of the alluvial plain although according to data collected for the top 6 ft within the limits of the PBA it is principally silts, sandy silts, and clays. The loess areas on the terrace are characterized by a relative homogenous silt in the subsurface, however these deposits have developed distict fragipan layers which are conducive to a perched water table during periods of prolonged or heavy rainfall. Plate 3 identifies the subsurface soil types within the limits of the reservation. As shown, the immediate subsurface materials at the study site consists predominantly of inorganic, low plasticity clay and subordinately of silt or sandy/clayey silt.

27. Average permeability values derived from U. S. Department of Agriculture studies[2] are low, suggesting that only small amounts of rainfall percolate through the upper soils to groundwater. No estimates of infiltration values were made by these studies and no other data on infiltration were located during this study except for a spraying test.[8] The spraying test was conducted for disposal of water on an area of Caddo-Pheba-Savannah soil association (surface soil ML, subsurface type ML, i.e. typical of the uplands found on the western part of the study site, reported permeability of 0.2 to 0.6 in./hr). A spraying rate of 0.09 in./hr exceeded the capacity of the soil to accept that volume of water by infiltration; as a result subsequent surface runoff occurred. While some infiltration occurred, test data were available for only the upper 12 in. The inadequacy of the soil to internally drain the volume of water being sprayed could have been caused by the high loading rate or a fragipan with a permeability much less than that reported for the general soil profile. The permeabilities shown on Plate 4 reflect the minimum values as indicated by the USDA[2] for any portion of the upper 6 ft of soil. At the study site permeabilities varying from 0.2 to 0.6 in/hr are indicated. Such values are high and indicate near free draining soil but hardpans usually modify these conditions.

28. Groundwater, elevation for the purposes of this report, is defined as the highest elevation of the saturated zone or water table. It is probable that this definition includes three different zones or elevation ranges within the confines of the PBA. Two of these zones may be of little consequence from the standpoint of being contaminated from surface infiltration. These zones are the occasional perched water table resulting from a shallow fragipan or hardpan and extended periods of rainfall and the artesian aquifer in the Sparta formation which underlies the Jackson group. While the Sparta is more than 600 ft below the surface, the artesian pressure raises the piezometric surface to about 100 ft below the site. The third zone, commonly referred to as the alluvial aquifer, is of primary concern for pollution potential. The alluvial aquifer underlies only the alluvial terrace and the alluvium plain.

29. Although the alluvial aquifer has not been investigated in detail at the PBA, some U. S. Geological Survey studies[9,10] have included portions of the PBA. The water monitoring study[11] initiated in 1967 required that 15 wells be completed to the alluvial aquifer. Two of these wells were located east of the study area and encountered water at a depth of 50 ft or an approximate elevation of 190 ft msl. The remainder of the wells were located in the southwest sector of the reservation and exhibited water level observations of approximately 195 ft msl. An earlier study presenting groundwater conditions in the Lower Arkansas River Valley indicated similar ranges in elevations for the groundwater surface. Portions of the piezometric maps presented in the earlier study are given in Figure 4 and 5 for the spring and fall 1959 conditions, respectively. These figures indicate the groundwater elevation at the study site should be expected to vary from about 195 to 200 ft msl.

30. No recent, alluvial groundwater elevations have been obtained within the PBA, but there is little reason to expect radical elevation changes. The nearness to the Arkansas River and the remoteness from heavy pumpage would suggest that the groundwater elevations are reasonably stable. Channel improvements in the Arkansas River have

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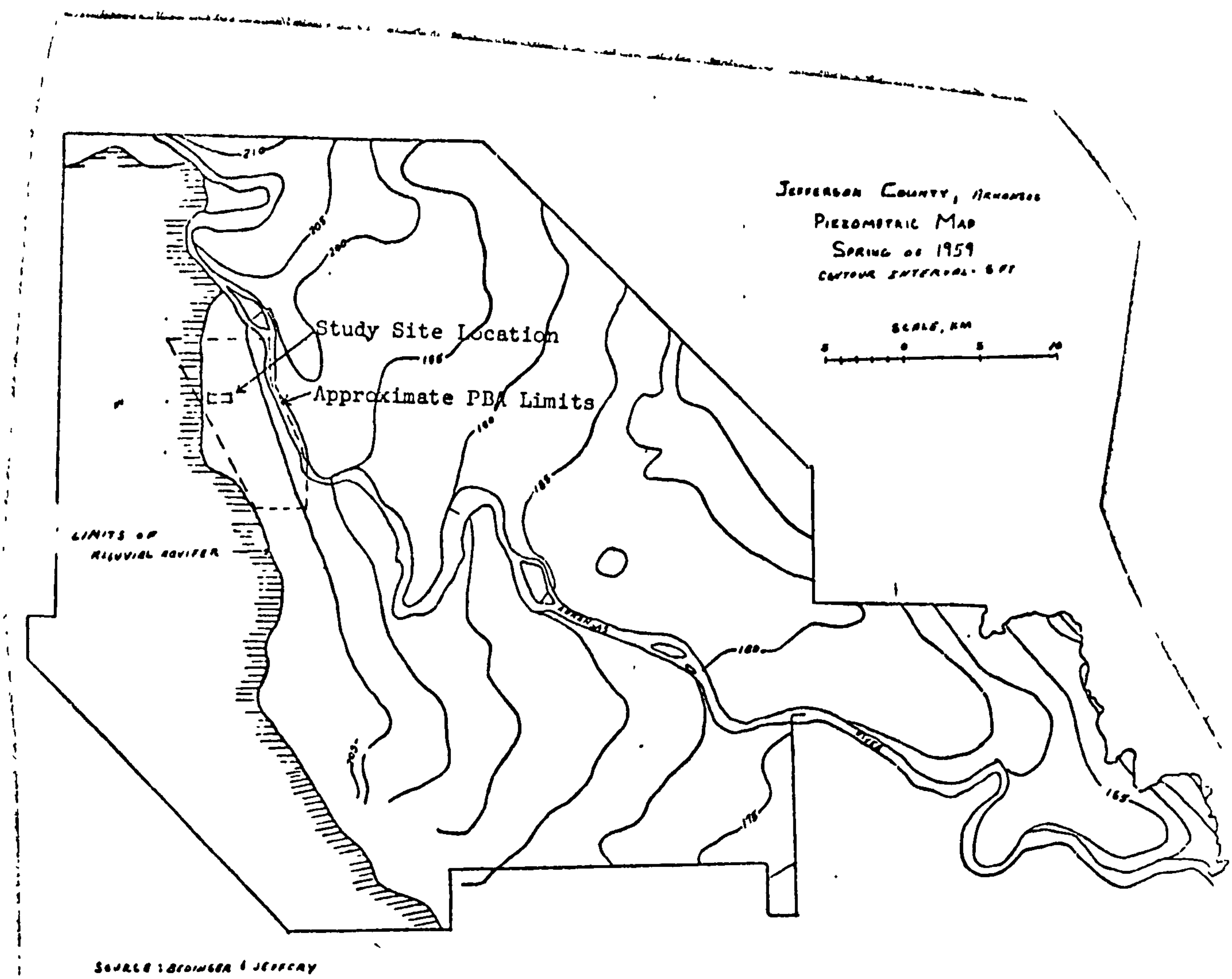
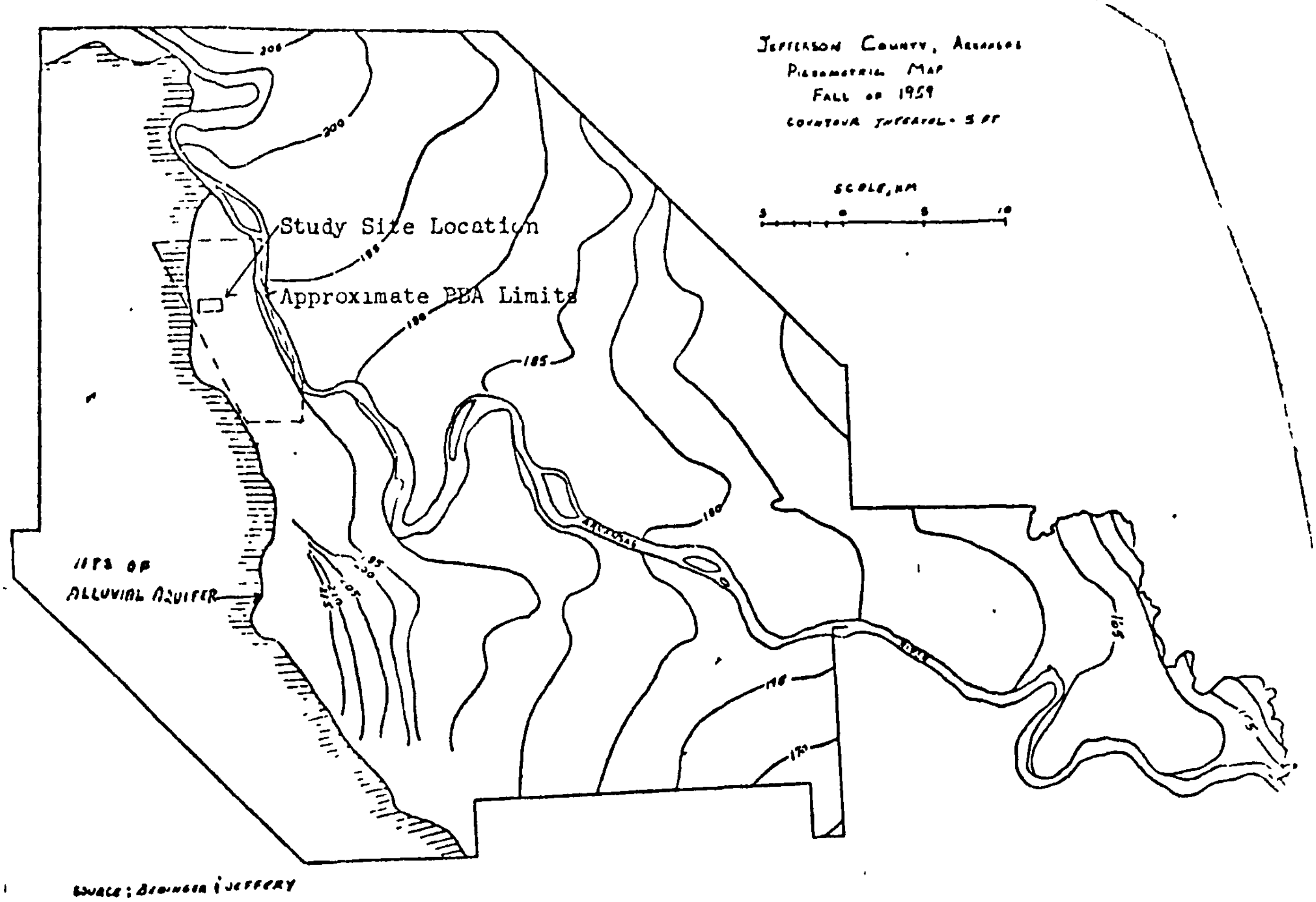


4-1 Jefferson County, Arkansas, Piezometric Surface, Spring 1959



Jefferson County, Arkansas, Piezometric Surface, Fall 1959 probably even reduced the possibility of fluctuations attributed to river stage variation. As apparent from Figures 4 and 5, the river was acting as a drain on the aquifer when the piezometric maps were made. It was suggested in recent conversations with U. S. Geological Survey personnel in Little Rock that the channel improvements resulting in a minimum pool elevation of 196 ft msl may create a constant recharge situation. An evaluation of this probability should be part of the future study.

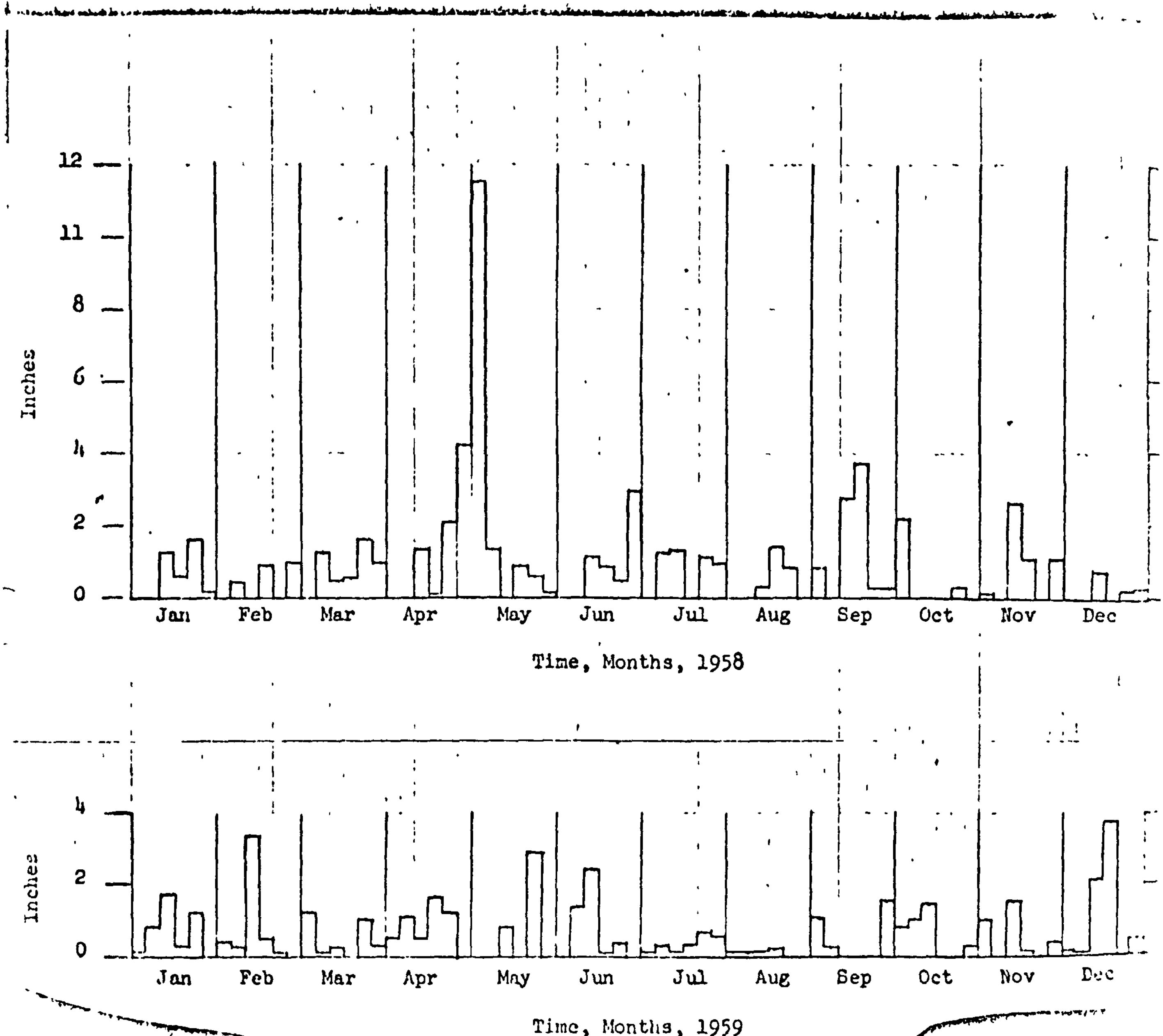
31. The saturated zone extends from the water table through the alluvial deposits to the top of the Jackson. Generally, the alluvium in the floodplain ranges in thickness from 76 to 195 ft with averages of approximately 100 ft thick. The bottom of the aquifer is the contact with the underlying Tertiary clays of the Jackson-Claiborne groups. These clays underlie the alluvium at an approximate elevation of 160 ft msl at Lock and Dam 5 on the Arkansas River north of the PBA and at an approximate elevation of 90 ft msl at Lock and Dam 4 south of the PBA. Some logs[10] show this group to be at an approximate elevation of 110 ft msl in the vicinity of the reservation. This Tertiary surface rises rapidly to the west and outcrops in the westward portion of the reservation.

32. The alluvial terraces (Quaternary) on the PBA are underlain by Tertiary deposits at elevations ranging from 250 ft msl (average outcrop contour) to confirmed elevations of 160 to 170 ft msl[7]. The elevation of the water table in the terraces was determined to be approximately 195 ft msl. These data indicated that the alluvial aquifer thickness would range from 0 ft in the western portion of the reservation to some 80 to 90 ft in the alluvium adjoining the River. No reliable estimates of north-south variation are possible, but with the approximate constant elevation of the Quaternary surface and the decreasing elevation of the Tertiary surface with constant water table elevation, it is expected that the thickness of the saturated zone would increase to the south as well as to the east.

33. Paleozoic bedrock lies about 3000 ft below the surface and exhibits no known or hypothesized effects on the groundwater regime of the reservation.

Rainfall

34. Precipitation at PBA averages about 50 in. per year. The distribution is reasonably uniform with the fall months receiving less than 4 in. and the winter and spring months receiving 4 to 6 in. of rain.[12] The precipitation is primarily rainfall as less than 2 in. per year of snow are usually recorded. Potential evaporation is approximately 58 in. per year[13] but actual evaporation of course depends upon ambient conditions and rainfall. Infiltration is dependent upon runoff and evaporation (including transpiration) but no quantitative figures were found. A graphic display of rainfall during two specific years, 1958 and 1959, at Pine Bluff[10] are shown in Figure 6, and Table 1 presents monthly averages[12] during the period of 1941-1970.



Pine Bluff, Arkansas, Precipitation, 1958-59

Table 1. Average Precipitation at Pine Bluff, Arkansas, 1941-1970

MONTHS	Average Precipitation, Inches
January	4.47
February	4.79
March	5.41
April	5.65
May	5.51
June	2.85
July	3.57
August	3.14
September	3.60
October	3.23
November	4.00
December	4.50

Source: U. S. Department of Commerce, 1973

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PART IV: CONCLUSIONS AND RECOMMENDATIONS

Conclusions

35. A considerable amount of data is available which is applicable to the definition of pollutant migration potential. These data have been generated by the PBA, the USGS, the Arkansas Geological Commission (AGC), and the U. S. Army Engineer Districts, Fort Worth, Little Rock, and Vicksburg.

36. The U. S. Army Engineer Districts (Fort Worth, Little Rock, and Vicksburg) have conducted or sponsored work associated with foundation investigations, floodplain planning, and environmental inventories. The exploratory boring and floodplain planning have contributed to the assessment of shallow, subsurface conditions while a later study, conducted by VTN Louisiana, Inc.[6] was a comprehensive survey of countywide conditions. The design and construction of two lock and dam systems on the bordering Arkansas River furnished valuable information on floodplain soils, geology, and groundwater depths.

37. The AGC work is primarily state oriented, but these portions applicable to the PBA and adjacent terrain are extractable and useful. Their collection of water well boring logs furnish substantial information on the surrounding county. A few specific county-oriented studies are available.

38. The USGS has monitored water levels in the Arkansas River Valley for an extended period of time. Information from these sources are valuable for predicting long-term trends and the boring logs are especially valuable for defining subsurface conditions.

39. The PBA has conducted several studies relative to the pollution migration potential. The study by Lachapelle, Brooks, and Trescott[11] presents a firm foundation on which to build future studies. The studies currently being conducted have a potential for substantially contributing to the knowledge of the subsurface. The latest study by Pinkham, Pearson, Fuller, and Bender[7] presents an overview of the PBA environment and

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furnishes a "first look" which is valuable in the initiation of programs to furnish detailed analysis.

Recommendations

40. A definite need exists for subsurface evaluation of both the saturated zone and zone of aeration over most of the PBA. The immediate concern is the subsurface soil and groundwater conditions underlying the study area as presented in Figure 1. Onsite drilling and appropriate sampling procedures will define strata characteristics and the installation of various types of post-drilling sampling equipment will permit monitoring of pollutant movement in the zone of aeration and the development of mathematical models to predict any long-term migration trends.

41. The saturated zone will have to be defined for the immediate site as well as the adjacent areas of the PBA in order to predict any movement within this zone. Piezometric surfaces need to be defined in terms of elevation, gradient, and movement. The saturated zone should be investigated to determine if stratification of movement occurs and if a dilution/distance relationship exists. Samples taken at existing well locations during drilling operations, and subsequent to drilling will permit definition of movement and possible mathematical modeling.

42. The program to accomplish these recommendations is presented in Appendix A.

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APPENDIX A: HYDROGEOLOGIC SAMPLING PROGRAM AT PINE BLUFF ARSENAL

Background

A1. A work statement, dated 1 October 1975, entitled "Soil Survey Work at Pine Bluff Arsenal" was prepared and submitted by the USAE Waterways Experiment Station (WES). Subsequent meetings between personnel of the Pine Bluff Arsenal (PBA), WES, and the Chemical Demilitarization and Installation Restoration staff of the Army Materiel Command resulted in an understanding of the scope of work to be accomplished by the study described by the work statement and the submission of "Justification of the FY 1977 Budget Request for Geologic/Hydrologic Studies at Pine Bluff Arsenal" on 11 November 1975.

A2. The latter document divided the study at the PBA site into three major parts: (Task I) Site Investigation, (Task II) Site Assessment, and (Task III) Site Monitoring. Task I was further subdivided into three phases: (A) Office study, (B) Field investigation, and (C) Laboratory testing. The first phase consisted of three efforts: (1) a literature survey, (2) a review of literature and compilation of preliminary site maps, and (3) formulation of a definitive plan of action. The efforts in phase (A) (Office study) of Task (I) were completed and described in this report. The results of the literature survey and review of literature and compilation of preliminary site maps were used to refine the preliminary plan of action, as originally described in the 11 November 1975 justification.

Plan of Action

A3. Further studies at the PBA will be initiated with phase (B) (Field investigations) of Task (I) (Site Investigation). While the remaining work at the PBA as presented in the above cited document of 11 November 1975 appears to fully justified on the basis of the completed portions of the work, it is recommended that the magnitude of the subsurface exploration and subsequent laboratory testing be expanded due to

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subtleties expected to occur in subsurface conditions. Figure A1 shows the locations of borings currently thought necessary for defining the subsurface conditions at the study site. These boring locations were selected to adequately define the substrata and the piezometric surface of that portion of the PBA lying between the study area and the Arkansas River. This area was isolated for detailed analysis for the following reasons:

- a. The geologic boundary between shallow aquifer in the terrace materials and the essentially dry formations to the west, which almost bisects the study area in a generally east-west direction, must be defined.
- b. The selected sector encompasses the shortest distance to a major water body, the Arkansas River.
- c. The sector covers all logical groundwater paths extending from the site.
- d. Existing PBA data will supplement subsequent piezometric determinations.
- e. The borings should permit delineation of any effects that the perennial stream, Phillips Creek, has on the water table.

A4. This tentative number of borings has resulted in an increase in the proposed budget due to increased drilling cost and laboratory testing. Similarly, the time requirements have been adjusted. The plan of action presented in the following pages reflect these changes to the document submitted on 11 November 1975.

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Task I: Site Investigation

Phase A: Office Study - (Completed and described in this report)

Effort 1. Site reconnaissance. Collect appropriate on-site data to refine preliminary maps.

- a. Surface soil samples
- b. Slope and drainage data
- c. Physical description of area of interest
- d. Land use
- e. Water level data on existing wells
- f. Interview personnel for waste generation, dates of disposal, disposal procedures, etc.

This effort will provide data to validate or refine the preliminary site maps and provide the basis to verify the plan for subsurface exploration as detailed below.

Effort 2. Subsurface exploration

- a. Preliminary
  - (1) Refine boring locations and depths
  - (2) Verify type of sampling and frequency, and identify other types of exploration such as refraction seismic, vibratory, geophysical logging, and fluid sampling that might be applicable.
- b. Conduct field exploration
  - (1) Drill necessary borings and prepare detailed boring logs.
  - (2) Obtain samples (soil and water)
  - (3) Installation of piezometers or lysimeters, as necessary
  - (4) Perform pumping tests for field permeability, as necessary.

A5. The subsurface exploration will be conducted using a WES drill crew which is proficient in the art of subsurface sampling or using PBA equipment with WES supervision. All WES drilling and sampling equipment,

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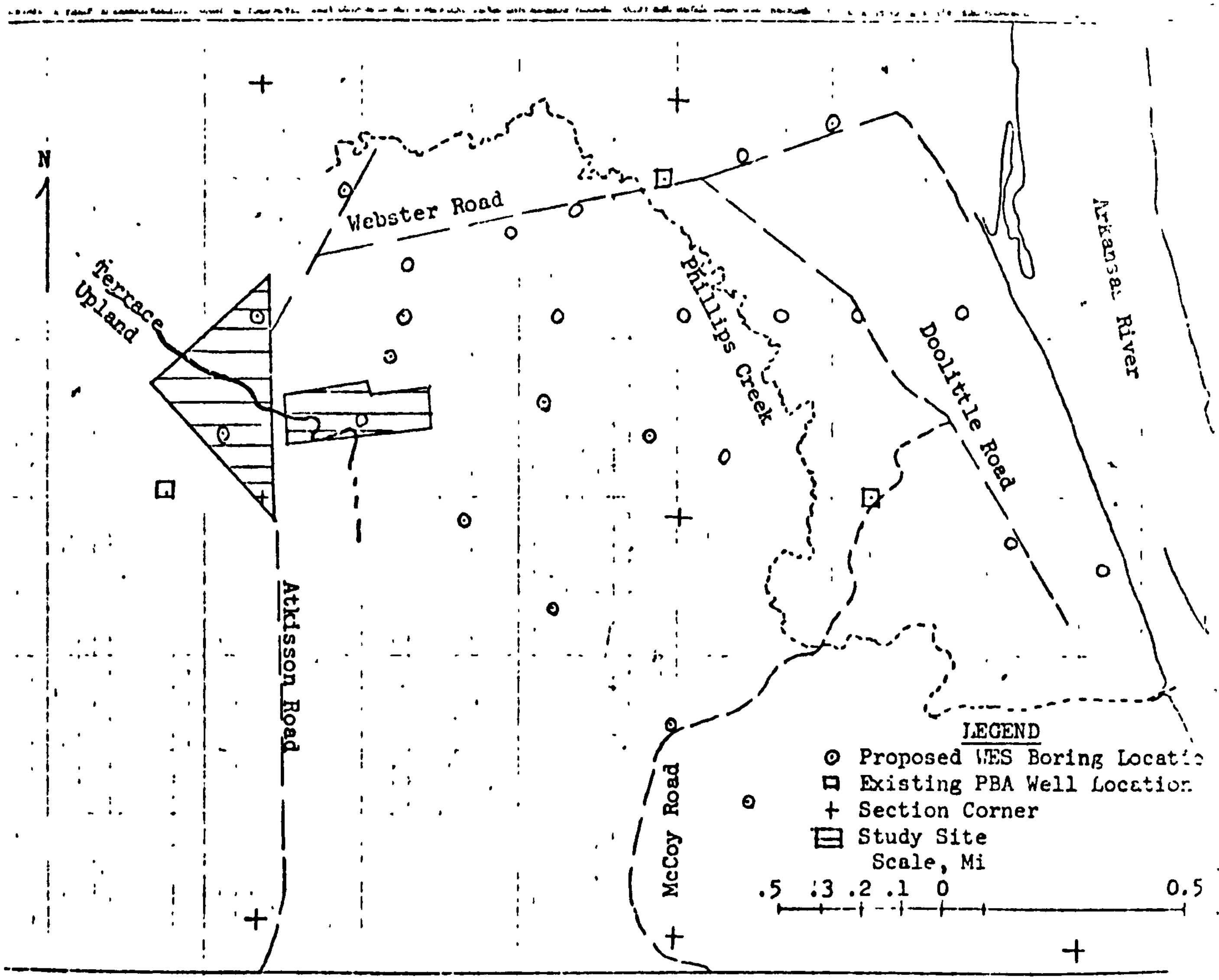

A1

PBA Study Site and Vicinity Showing Proposed Boring Locations tubing, and equipment for preparing and preserving samples, etc., will be available for almost any conceivable condition. The installation of piezometers or lysimeters will be based on the field data collected. The cost estimate, shown later, assumes subsurface exploration will be conducted by a WES drill crew.

Phase C: Laboratory testing

Effort 1. Physical tests of soil

- a. Density
- b. Water content
- c. Classification
- d. Clay mineralogy

A6. All samples obtained will be carefully preserved and crated for shipment. The above tests are the minimum effort necessary to obtain recommended physical properties to provide necessary detail for site evaluation and assessment. Other tests may be included to complete the site description, but is not included in the cost estimate.

Effort 2. Tests for contaminants. It is assumed that all chemical/pesticide tests will be conducted by PBA equipment/personnel. However, if desired by PBA, WES will be willing to suggest appropriate tests based upon previous and ongoing work. In preparing the cost estimate no allowance is shown for WES to conduct tests for contaminants.

A7. Upon the completion of Task I, all data pertaining to the subsurface hydrogeology conditions (in terms of descriptions of strata and their physical properties, contaminants present and their concentration and position) will have been collected. Additionally, suitable instruments will have been installed to provide for the monitoring of long-range effects and to verify the results of the assessment task.

Task II: Site Assessment

A8. Once data have been collected, evaluated, and placed into proper format, the boundary-value problem can be described. Such description will include depth, thickness, uniformity, extent, permeability

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Effort 3. Obtain predictions. Based on PBA input, future site activities will be described and used as input to the model to predict future effects of engineering activities of the site.

Task III: Site Monitoring

A10. Once the site data have been collected, synthesized, and cast into a form to properly calibrate the geological/hydrological model, the predictions resulting therefrom exhaust the possibilities in terms of analytical capabilities at the present time. Predictions of future changes must be verified. If subsequently collected data are deemed to be in substantial disagreement with predictions, the model must be further refined. However, to substantiate predictions, a sampling program of both soil/water samples must be established. In either case, the assaying of samples (whether soil or water) can be handled with present PBA capabilities. At this stage it is necessary to mention that the plan of action recognizes that site monitoring will be required. It is likewise recognized that borings made during the subsurface exploration can be subordinately used to obtain water quality samples. Subsurface samples of soil for subsequent contaminant assessment will have to be obtained from additional borings specifically for that purpose. It is envisioned here that both subsurface soil and water samples can be obtained by PBA equipment and personnel. Similarly, it is assumed that assaying of the samples can be made by PBA personnel.

A11. Personnel of WES will be available to aid in site monitoring activities as requested on a cost reimbursable basis. In any event, such activities are not envisioned as part of FY 77 requirements and are not included in the cost/time estimate in the followig paragraphs.

Not included
revised
3 or 4 times

AT

PRELIMINARY

APPENDIX H

BUILDING INVENTORY

PINE BLUFF ARSENAL

BUILDING INVENTORY
PINE BLUFF ARSENAL

Building Number	Description	Building Number	Description
Non-Industrial			
42900	Ammunition Demil Facility	60440	Loading - Unloading Docks
55000	Other	60520	Other
55020	Administrative	60610	General Purpose Warehouse
55030	Other	60620	
55040	Other	60630	
55050	Other	60640	
55060	Sentry Station	60650	
55061	Septic Tank Drainage Field	60660	General Purpose Warehouse
55110	General Purpose Warehouse	60710	High Explosive Magazine
55115	General Purpose Warehouse	60720	High Explosive Magazine
55220	Other	60730	High Explosive Magazine
55320	Other	60740	High Explosive Magazine
55330	Septic Tank Drainage Field	61010	Smokeless PO Magazine
55410	General Purpose Warehouse	61020	Fallout Shelter
55415	General Purpose Warehouse	61030	Smokeless PO Magazine
60060	General Purpose Warehouse	61040	
60070	Other	61050	
60080	Sewage Pump	61060	
60090	Administrative	61070	
60100	Inflamable Material Storehouse	61080	
60320	Loading - Unloading Docks	61090	
60340	Loading - Unloading Docks	61100	
60400	Other	61110	
60401	Lumber Shed	61120	
60402	Lumber Shed	61130	
60420	Loading - Unloading Docks	61140	Smokeless PO Magazine

Building Number	Description	Building Number	Description
61150	Smokeless PO Magazine	61470	High Explosive Magazine
61160		61480	
61170		61490	
61180		61500	
61190		61510	
61200		61520	
61210		61530	
61220		61540	
61230		61550	
61240		61560	
61250	Smokeless PO Magazine	61570	
61260	High Explosive Magazine	61580	High Explosive Magazine
61270	Smokeless PO Magazine	61590	Smokeless PO Magazine
61280		61600	High Explosive Magazine
61290		61610	Smokeless PO Magazine
61300		61620	Smokeless PO Magazine
61310		61630	Smokeless PO Magazine
61320	Smokeless PO Magazine	61640	High Explosive Magazine
61330	High Explosive Magazine	61650	High Explosive Magazine
61340	High Explosive Magazine	61660	High Explosive Magazine
61350	High Explosive Magazine	61670	High Explosive Magazine
61360	High Explosive Magazine	61680	High Explosive Magazine
61370	High Explosive Magazine	61690	Smokeless PO Magazine
61380	Smokeless PO Magazine	61700	
61390		61710	
61400		61720	
61410		61730	
61420		61740	Smokeless PO Magazine
61430		61750	Fuse Detonator Magazine
61440	Smokeless PO Magazine	61760	Fuse Detonator Magazine
61450	High Explosive Magazine	61770	Fuse Detonator Magazine
61460	High Explosive Magazine	61780	Smokeless PO Magazine

Building Number	Description	Building Number	Description
61790	Smokeless PO Magazine	62110	Smokeless PO Magazine
61800	Smokeless PO Magazine	62120	
61810	Smokeless PO Magazine	62130	
61820	Smokeless PO Magazine	62140	
61830	Smokeless PO Magazine	62150	
61840	Fuse Detonator Magazine	62160	Smokeless PO Magazine
61850		62170	High Explosive Magazine
61860		62180	
61870		62190	
61880		62200	
61890	Fuse Detonator Magazine	62210	
61900	Smokeless PO Magazine	62220	
61910		62230	
61920		62240	
61930		62250	
61940		62260	
61950	Smokeless PO Magazine	62270	
61960	High Explosive Magazine	62280	
61970	High Explosive Magazine	62290	
61980	High Explosive Magazine	62300	
61990	High Explosive Magazine	62310	
62000	High Explosive Magazine	62320	
62010	Fallout Shelter	62330	High Explosive Magazine
62020	Smokeless PO Magazine	62340	Fuse Detonator Magazine
62030		62350	Fuse Detonator Magazine
62040		62360	Fuse Detonator Magazine
62050		62370	High Explosive Magazine
62060		62380	
62070		62390	
62080		62400	
62090		62410	
62100	Smokeless PO Magazine	62420	High Explosive Magazine

Building Number	Description
62430	High Explosive Magazine
62440	High Explosive Magazine
62450	High Explosive Magazine
62460	Fuse Detonator Magazine
62470	Fuse Detonator Magazine
62480	High Explosive Magazine
62490	Fuse Detonator Magazine
62500	High Explosive Magazine
62510	Fuse Detonator Magazine
62520	
62530	
62540	
62550	
62560	Fuse Detonator Magazine
62570	High Explosive Magazine
82580	
62590	
62600	
62610	
62620	
62630	High Explosive Magazine
62640	Fuse Detonator Magazine
62650	Fuse Detonator Magazine
62660	High Explosive Magazine
62670	
62680	
62690	
62700	
62710	
62720	
62730	
62740	High Explosive Magazine
62750	High Explosive Magazine
62760	
62770	
62780	
62790	
62800	
62810	
62820	
62830	High Explosive Magazine
62840	Fuse Detonator Magazine
62850	Fuse Detonator Magazine
62860	Fuse Detonator Magazine
62865	Sentry Station
62870	High Explosive Magazine
62880	
62890	
62900	
62910	
62920	
62930	
62940	High Explosive Magazine
62950	Fuse Detonator Magazine
62960	
62970	
62980	
62990	
63000	Fuse Detonator Magazine
63010	Loading - Unloading Docks
63100	Other
63101	Operations, General Purpose
63102	Other
63110	Ammunition Renv Shop

Building Number	Description
63120	Smokeless PO Magazine
63200	
63210	
63220	
63230	
63300	
63310	
63320	
63410	Smokeless PO Magazine
64010	High Explosive Magazine
64020	Vacant
64100	Loading - Unloading Docks
81100	General Storehouse
81200	
81210	
81300	
81310	
81330	
81400	
81410	
81420	
81430	
81510	
81520	
81530	
81600	
81610	
81620	General Storehouse
Industrial	
10020	Post Headquarters

Building Number	Description
10030	Cafeteria
10040	Telephone Exchange
10050	Fire Station
10075	Golf Club House
10210	Flagpole
11010	Vacant
11020	Sentry Station
11030	Vacant
11050	Vacant
12300	Family Housing
12302	
12304	
12306	
12308	
12310	
12312	Family Housing
12415	Septic Tank Drainage Field
12510	Public Toilet
12550	Other
12560	Other
12600	Rod and Gun Club
13000	Elevated Water Storage Tank
13010	Administrative
13020	Administrative
13030	Administrative
13040	Dispensary
13050	Dispensary
13060	Credit Union
13080	Laboratory
13090	General Installation
13100	Other
13110	General Storehouse

Building Number	Description
13120	Steam Plant Power
13700	Family Housing
13701	
13702	
13703	
13704	
13705	
13706	
13707	
13708	
13709	Family Housing
14013	Water Pump NP
14014	Water Pump NP
14020	Medical Cal Pro Ldg
15011	Det Strength
15012	
15022	
15031	
15042	
15051	
15062	
15071	
15082	
15091	
15092	Det Strength
15103	General Storehouse
15210	Open Mess, Officer
15215	Outdoor Swimming Pool
15330	BOQ
15350	BOQ
16020	Open Mess, Noncommissioned Officer
16040	Signal Field Maintenance Shop

Building Number	Description
16060	Theater
16075	Outdoor Swimming Pool
16110	Vacant
16150	General Storehouse
16210	Enlisted Housing
16220	Enlisted Housing
16230	Other
16250	General Storehouse
16360	EM Service Club
16270	Enlisted Personnel Mess
13610	Recreation Building
16340	Exchange Branch
16420	Gas Station
16430	Auto Self Help Garage
16450	Other
16490	General Purpose Magazine
16500	Kennel
17050	Sewage Pump
17996	Other
22600	Scale House
23100	Sub Station
23310	General Purpose Warehouse
23330	General Purpose Warehouse
23350	General Purpose Warehouse
23370	Administrative
23390	General Purpose Warehouse
23421	Inflamable Material Storehouse
23422	Inflamable Material Storehouse
23445	Lumber Shed
23450	Lumber Shed
24010	Sentry Station
24020	Sentry Station

Building Number	Description	Building Number	Description
24030	Sentry Station	31630	Other
24500	Other	31631	Other
24550	Sewage Pump	31632	Other
24610	General Purpose Warehouse	31640	Other
24761	Vacant	31650	General Storehouse
24770	General Purpose Warehouse	31670	Other
31010	Vacant	31672	Vacant
31013	Water Pump NP	31710	Fuse Detonator Magazine
31014	Water Pump NP	31720	Other
31015	Water Pump NP	31730	Other
31060	Steam Plant Power	31731	Other
31080	General Purpose Warehouse	31740	Fuse Detonator Magazine
31100	Vacant	31750	Other
31150	Vacant	31810	Fuse Detonator Magazine
31210	General Purpose Warehouse	31820	Other
31230	General Purpose Warehouse	31830	Other
31250	General Purpose Warehouse	31840	Fuse Detonator Magazine
31270	General Purpose Warehouse	31850	Vacant
31310	Inflamable Material Storehouse	31860	Other
31330	Inflamable Material Storehouse	31870	Vacant
31420	Inflamable Material Storehouse	32000	Vacant
31435	Other	3201[illegible]	Sentry Station
31440	Inflamable Material Storehouse	32011	No Current Description
31530	Other	32013	Water Pump NP
31530	Other	32014	Water Pump NP
31531	Other	32030	Motor Repair Shop
31532	Vacant	32035	Motor Repair Shop
31540	Other	32050	Gas Station
31550	General Storehouse	32060	Steam Plant Power
31570	Other	32070	Other
31572	Vacant	32080	FE Maintenance Shop
31620	Other	32090	General Purpose Warehouse

Building Number	Description
32091	Inflamable Material Storehouse
32100	Vacant
32130	Other
32131	Other
32150	Administrative
32210	General Purpose Warehouse
32230	General Purpose Warehouse
32250	General Purpose Warehouse
32270	General Purpose Warehouse
32310	Inflamable Material Storehouse
32330	Inflamable Material Storehouse
32335	Other
32420	Inflamable Material Storehouse
32440	Inflamable Material Storehouse
32480	Transit Shed
32510	Other
32520	Other
32530	Other
32532	Other
32534	Vacant
32535	Other
32536	
32538	
32540	
32550	
32570	
32572	
32610	
32620	
32630	Other
32631	Vacant
32632	Vacant

Building Number	Description
32640	Other
32650	Other
32670	Other
32690	Other
32710	Fuse Detonator Magazine
32720	Other
32730	Fuse Detonator Magazine
32740	Fuse Detonator Magazine
32750	FE Maintenance Shop
32810	Fuse Detonator Magazine
32820	Other
32830	Other
32840	Fuse Detonator Magazine
32850	Other
32860	Other
32870	Other
32880	Vacant
33000	Cafeteria
33010	Sentry Station
33013	Water Pump NP
33014	Water Pump NP
33015	Water Pump NP
33060	Steam Plant Power
33080	Other
33100	Change House
33150	Vacant
33210	General Purpose Warehouse
33230	General Purpose Warehouse
33250	General Purpose Warehouse
33270	General Purpose Warehouse
33310	Inflamable Material Storehouse
33320	Vacant

Building Number	Description	Building Number	Description
33330	Inflamable Material Storehouse	33860	Other
33420	Inflamable Material Storehouse	33870	Other
33440	Inflamable Material Storehouse	33910	Other
33480	Transit Shed	34001	Vacant
33520	Other	34010	Water Pump NP
33525	Other	34011	Vacant
33530	Other	34012	
33531	Other	34013	
33532	Storage	34014	
33540	Other	34015	
33550		34016	
33570		34017	
33572		34021	
33620		34022	
33630	Other	34023	
33631	Vacant	34024	
33632	Other	34025	
33640	Other	34026	
33650	Other	34027	
33670	Other	34031	
33672	Other	34032	
33710	Fuse Detonator Magazine	34033	
33720	Other	34034	
33730	Vacant	34035	
33740	Fuse Detonator Magazine	34036	
33750	Other	34037	
33760	Other	34042	
33810	Fuse Detonator Magazine	34044	
33820	Other	34046	
33830	Other	34051	
33840	Other	34052	
33850	Vacant	34053	Vacant

Building Number	Description	Building Number	Description
34054	Vacant	34112	Inflamable Material Storehouse
34055		34115	Medical Cal Pro Ldg
34056		34117	Inflamable Material Storehouse
34057		34118	Other
34061		34120	Change House
34063		34130	Medical Cal Pro Ldg
34065		34133	Medical Cal Pro Ldg
34067		34135	Medical Cal Pro Ldg
34071		34140	Steam Plant Power
34072		34160	Cafeteria
34073		34170	Medical Cal Pro Ldg
34074		34220	General Purpose Warehouse
34075		34250	General Purpose Warehouse
34076		34310	Vacant
34077		34350	Other
34081		34360	Other
34082		34380	Fuse Detonator Magazine
34083		34430	General Purpose Warehouse
34084		34440	General Purpose Warehouse
34085		34450	General Purpose Warehouse
34086		34460	General Purpose Warehouse
34087		34630	Other
34091		34640	Other
34092		34650	Other
34093		34660	Other
34094		34680	Vacant
34095		34820	Other
34096		34860	Fuse Detonator Magazine
34097	Vacant	34909	Grease Racks
34101	Sentry Station	34910	FE Maintenance Shop
34110	Medical Cal Pro Ldg	34911	Other
34111	Other	34913	General Storehouse

Building Number	Description	Building Number	Description
34914	Gas Station	41320	Fuse Detonator Magazine
34930	FE Maintenance Shop	41330	
34950	Sentry Station	41340	
34960	FE Maintenance Shop	41350	
34961	FE Facilities	41360	
34970	Administrative	41370	
40010	Sentry Station	41380	
40011	Public Toilet	41410	
41010	Fuse Detonator Magazine	41420	
41020	Fuse Detonator Magazine	41430	
41030	Fuse Detonator Magazine	41440	
41040	Other	41450	
41050	General Purpose Warehouse	41460	
41060	Fuse Detonator Magazine	41470	
41070		41480	
41080		41510	
41110		41520	
41120		41530	
41130		41540	
41150		41550	
41160	Fuse Detonator Magazine	41560	
41170	Other	41570	
41180	Fuse Detonator Magazine	41580	
41210		41610	
41220		41620	
41230		41630	
41240		41640	
41250		41650	
41260		41660	
41270		41670	
41280		41680	
41310	Fuse Detonator Magazine	41710	Fuse Detonator Magazine

Building Number	Description	Building Number	Description
41720	Fuse Detonator Magazine	42822	Sewage Treatment Plant
41730		43000	Elevated Water Storage Tank
41740		44100	Cafeteria
41750		44101	Sentry Station
41760		44102	Sentry Station
41770		44110	Medical Cal Pro Ldg
41780		44120	Steam Plant Power
41810		44200	Sewage Pump
41820		44212	Other
41830		44213	
41840		44214	
41850		44215	
41860		44219	
41870		44220	Other
41880	Fuse Detonator Magazine	44300	Administrative
42000	Elevated Water Storage Tank	44301	Other
42010	Water Well with PS	44302	Septic Tank Drainage Field
42013	Water Pump NP	50020	General Purpose Warehouse
42020	Water Well with PS	50040	General Purpose Warehouse
42030	Water Well with PS	50060	General Purpose Warehouse
42200	Water Treatment Plant	50080	General Purpose Warehouse
42210	Water Treatment Plant	50100	Sub Station
42212	Fuel Storage Tank	50110	General Purpose Warehouse
42213	Water Treatment Plant	50120	
42215	Water Treatment Plant	50130	
42216	Water Treatment Plant	50140	
42225	Septic Tank Drainage Field	50150	
42300	Incinerator	50160	
42410	Vacant	50170	
42600	Sewage Pump	50180	General Purpose Warehouse
42750	Sewage Treatment Plant	50190	Water Well with PS
42820	Sewage Pump	50220	General Purpose Warehouse

Building Number	Description
50230	General Purpose Warehouse
50240	
50250	
50270	
50290	
50310	
50340	
50360	
50410	
50430	
50510	
50610	
50810	
50910	General Purpose Warehouse
51190	Water Pump NP
51420	Divisional Headquarters
51570	RR Equipment Maintenance Shop
51630	Motor Repair Shop
51650	Diesel Station
53013	Water Pump NP
53100	Other
53150	Vacant
53180	No Current Description
53220	Vacant
53221	Vacant
53225	Vacant
53250	Vacant
53300	Fuel Storage Tank
53301	Fuel Storage Tank
53321	Vacant
53350	Vacant
53450	Vacant
53600	Vacant
53890	Vacant
53900	Vacant
53910	Other
53990	Other
53991	Other
54010	General Purpose Warehouse
54110	General Purpose Warehouse
54130	Vacant
54131	Vacant
54140	Vacant
54141	Vacant
54150	Vacant
54151	Other
54160	Vacant
54161	Vacant
54180	Elevated Water Tank NP
54190	No Current Description
54240	Vacant
54241	
54261	
54262	
54270	
54280	
54290	
54291	
54292	
54293	
54300	
54310	
54325	
54340	Vacant

Building Number	Description
54341	Vacant
54350	
54360	
54361	
54362	
54430	
54431	
54440	
54441	
54442	
54450	
54460	
54461	Vacant
54480	Elevated Water Tank NP
54500	Administrative
54700	Vacant
56150	Chlorinator
56810	Sewage Treatment Plant
56860	Sewage Treatment Plant
56900	Sewage Pump
57013	Water Pump NP
57190	Water Pump NP
60020	Civilian Personnel
64040	Sentry Station
64050	Sentry Station
64110	Fuse Detonator Magazine
64120	Fuse Detonator Magazine
64130	Fuse Detonator Magazine
64140	Fuse Detonator Magazine
64150	Igloo Storage
64151	Other
64210	Fuse Detonator Magazine
64220	Fuse Detonator Magazine
64230	Fuse Detonator Magazine
64240	Fuse Detonator Magazine
64250	Igloo Storage
64251	Vacant
64310	Fuse Detonator Magazine
64320	Fuse Detonator Magazine
64330	Fuse Detonator Magazine
64340	Fuse Detonator Magazine
64350	Igloo Storage
64351	Vacant
64360	Igloo Storage
64361	Vacant
64420	Fuse Detonator Magazine
64440	Fuse Detonator Magazine
64450	Fuse Detonator Magazine
64460	Igloo Storage
64461	Vacant
74013	Water Pump NP
77910	Vacant
77950	Other
77960	Other
81020	Other
81021	Septic Tank Drainage Field
81111	Other
83010	Igloo Storage
83011	Vacant
83020	Igloo Storage
83021	Vacant
83110	Igloo Storage
83111	Vacant
83120	Igloo Storage

Building Number	Description
83121	Vacant
83210	Igloo Storage
83211	Vacant
83220	Igloo Storage
83221	Vacant
83310	Igloo Storage
83311	Vacant
83320	Igloo Storage
83321	Vacant
83410	Igloo Storage
83411	Vacant
83420	Igloo Storage
83421	Vacant
83430	Igloo Storage
83431	Vacant
83510	Igloo Storage
83511	Vacant
83520	Igloo Storage
83521	Vacant
83530	Igloo Storage
83531	Vacant
83610	Igloo Storage
83611	Vacant
83620	Igloo Storage
83621	Vacant
83630	Igloo Storage
83631	Vacant
84010	Igloo Storage
84011	Vacant
84020	Igloo Storage
84021	Vacant
84030	Igloo Storage
84031	Vacant
84110	Igloo Storage
84111	Vacant
84120	Igloo Storage
84121	Vacant
84210	Igloo Storage
84211	Vacant
84220	Igloo Storage
84221	Vacant
84230	Igloo Storage
84231	Vacant
84310	Igloo Storage
84311	Vacant
84320	Igloo Storage
84321	Vacant
84410	Igloo Storage
84411	Vacant
84420	Igloo Storage
84421	Vacant
84430	Igloo Storage
84431	Vacant
84440	Igloo Storage
84441	Vacant
84450	Igloo Storage
84451	Vacant
85010	Igloo Storage
85011	Vacant
85020	Igloo Storage
85021	Vacant
85030	Igloo Storage
85031	Vacant
85040	Igloo Storage

Building Number	Description	Building Number	Description
85041	Vacant	85330	Igloo Storage
85120	Igloo Storage	85331	Vacant
85121	Vacant	85340	Igloo Storage
85130	Igloo Storage	85341	Vacant
85131	Vacant	85350	Igloo Storage
85140	Igloo Storage	85351	Vacant
85141	Vacant	93132	Water Well with PS
85150	Igloo Storage	93232	Water Well with PS
85151	Vacant	93332	Water Well with PS
85160	Igloo Storage	93432	Water Well with PS
85161	Vacant	93820	Industrial Waste Treatment
85230	Igloo Storage	96621	Vacant
85231	Vacant		

APPENDIX I

ANALYSIS OF EXISTING FACILITIES/ENVIRONMENTAL ASSESSMENT REPORT

PINE BLUFF ARSENAL

REVISED 1 DECEMBER 1976

A copy of this report can be obtained from:

Department of the Army
Headquarters, Pine Bluff Arsenal
Pine Bluff, Arkansas 71601

APPENDIX J

US AEHA WASTE TREATABILITY STUDY NO. 24-044-73/76

13 FEBRUARY - 21 MARCH 1974

A copy of this report can be obtained from:

Department of the Army
US Army Environmental Hygiene Agency
Aberdeen Proving Ground, MD 21010

APPENDIX K

US AEHA WATER QUALITY ENGINEERING SURVEY NO. 24-002-73

A Copy of this report can be obtained from:

Department of the Army
US Army Environmental Hygiene Agency
Aberdeen Proving Ground, MD 21010

APPENDIX L

US AEHA INSTALLATION RESTORATION PROGRAM REPORT NO. 99-065-75/76

PINE BLUFF ARSENAL

28 - 31 JULY 1975

A copy of this report can be obtained from:

Department of the Army
US Army Environmental Hygiene Agency
Aberdeen Proving Ground, MD 21010

APPENDIX M

EDGEWOOD ARSENAL SPECIAL PUBLICATION EB-SP-74025

PRELIMINARY ENVIRONMENTAL SURVEY

PINE BLUFF ARSENAL

DECEMBER 1972

A copy of this report can be obtained from:

Department of the Army
Chemical Systems Laboratory (DRDAR-CLL)
Aberdeen Proving Ground, MD 21010

APPENDIX N

PINE BLUFF ARSENAL REGULATION 420-5

SOLID WASTE DISPOSAL

A copy of this report can be obtained from:

Department of the Army
Headquarters, Pine Bluff Arsenal
Pine Bluff, Arkansas 71601

APPENDIX O

STANDING OPERATING PROCEDURE NUMBER 71-7

OPERATIONS OF SEWAGE TREATMENT PLANTS

PINE BLUFF ARSENAL

A copy of this report can be obtained from:

Department of the Army
Headquarters, Pine Bluff Arsenal
Pine Bluff, Arkansas 71601

APPENDIX P

US AEHA SOLID WASTE SURVEY NO. 26-001-73/74

PINE BLUFF ARSENAL

4 - 6 JUNE 1973

A copy of this report can be obtained from:

Department of the Army
US Army Environmental Hygiene Agency
Aberdeen Proving Ground, MD 21010

APPENDIX Q

US AEHA WATER QUALITY GEOHYDROLOGIC CONSULTATION NO. 24-004-74

PINE BLUFF ARSENAL

16 - 20 JULY 1973

A copy of this report can be obtained from:

Department of the Army
US Army Environmental Hygiene Agency
Aberdeen Proving Ground, MD 21010

APPENDIX R

EDGEWOOD ARSENAL TECHNICAL REPORT EO-TR-76077

EFFECTS OF ELEMENTAL PHOSPHORUS ON THE BIOTA OF YELLOW LAKE

PINE BLUFF ARSENAL

MARCH 1974 - JANUARY 1975

A copy of this report can be obtained from:

Department of the Army
Chemical Systems Laboratory (DRDAR-CLL)
Aberdeen Proving Ground, MD 21010

APPENDIX S

EDGEWOOD ARSENAL TECHNICAL REPORT EB-R-76038

RESULTS OF AQUATIC SURVEYS AT PINE BLUFF ARSNEAL

SEPTEMBER 1973 - OCTOBER 1974

A copy of this report can be obtained from:

Department of the Army
Chemical Systems Laboratory (DRDAR-CLL)
Aberdeen Proving Ground, MD 21010

APPENDIX T

PINE BLUFF ARSENAL INPUT

23 DECEMBER 1977

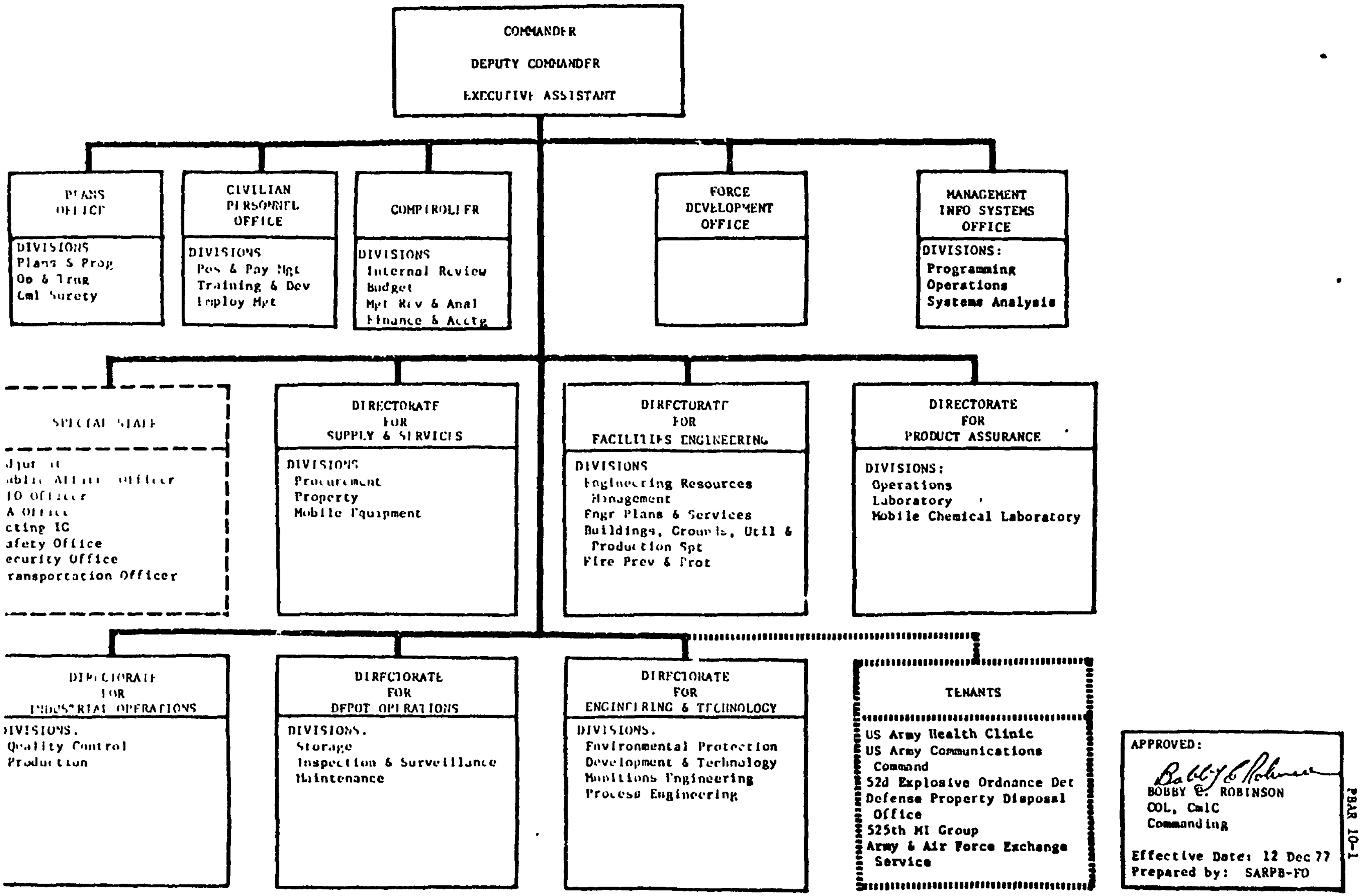
CHAPTER 3

MISSION

3-1. Mission. To operate pilot production, pre-production, and limited production facilities for the manufacture of smoke, riot control, incapacitating, incendiary, and pyrotechnic mixes and/or munitions as assigned; to produce or manufacture chemical, smoke, riot control, incapacitating, incendiary and other pyrotechnic mixes and/or munitions to supplement commercial industrial capacity; to operate limited production facilities in the manufacture of chemical defensive items, to include impregnation of clothing and assembly of protective masks; to support research, development and engineering activities of other US Army Materiel Development and Readiness Command (DARCOM) activities through operation of the facilities cited above, including manufacturing technology, origination and implementation of improvement and modernization projects; to receive, store, perform surveillance, renovate, demilitarize, and ship chemical, conventional, riot control, smoke, and incendiary agents and/or munitions, industrial components and strategic materials; to receive, store and ship supplies and equipment of other governmental agencies; to perform planning in support of mobilization requirements and schedules prepared by Headquarters, US Army Armament Materiel Readiness Command (ARRCOM) in support of the Industrial Readiness Assurance Program for ARRCOM items; to maintain facilities and equipment, active or standby, to assure capability as required for current and future production; to provide testing services and technical advice or assistance to industry in the production of chemical, riot control, smoke and incendiary agents and/or munitions, as required; to provide administrative and logistic support to installation mission activities and attached or tenant activities; to administer a procurement program in support of the installation's mission; to maintain a security program IAW AR 50-6; to operate a mobile chemical laboratory at various DARCOM installations; and to perform installation restoration and chemical demilitarization activities in support of DA Project Manager.

UNITED STATES ARMY ARMAMENT MATERIEL READINESS COMMAND

PINE BLUFF ARSENAL

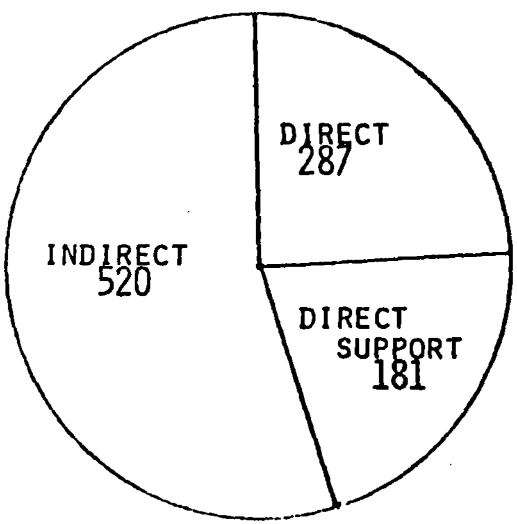


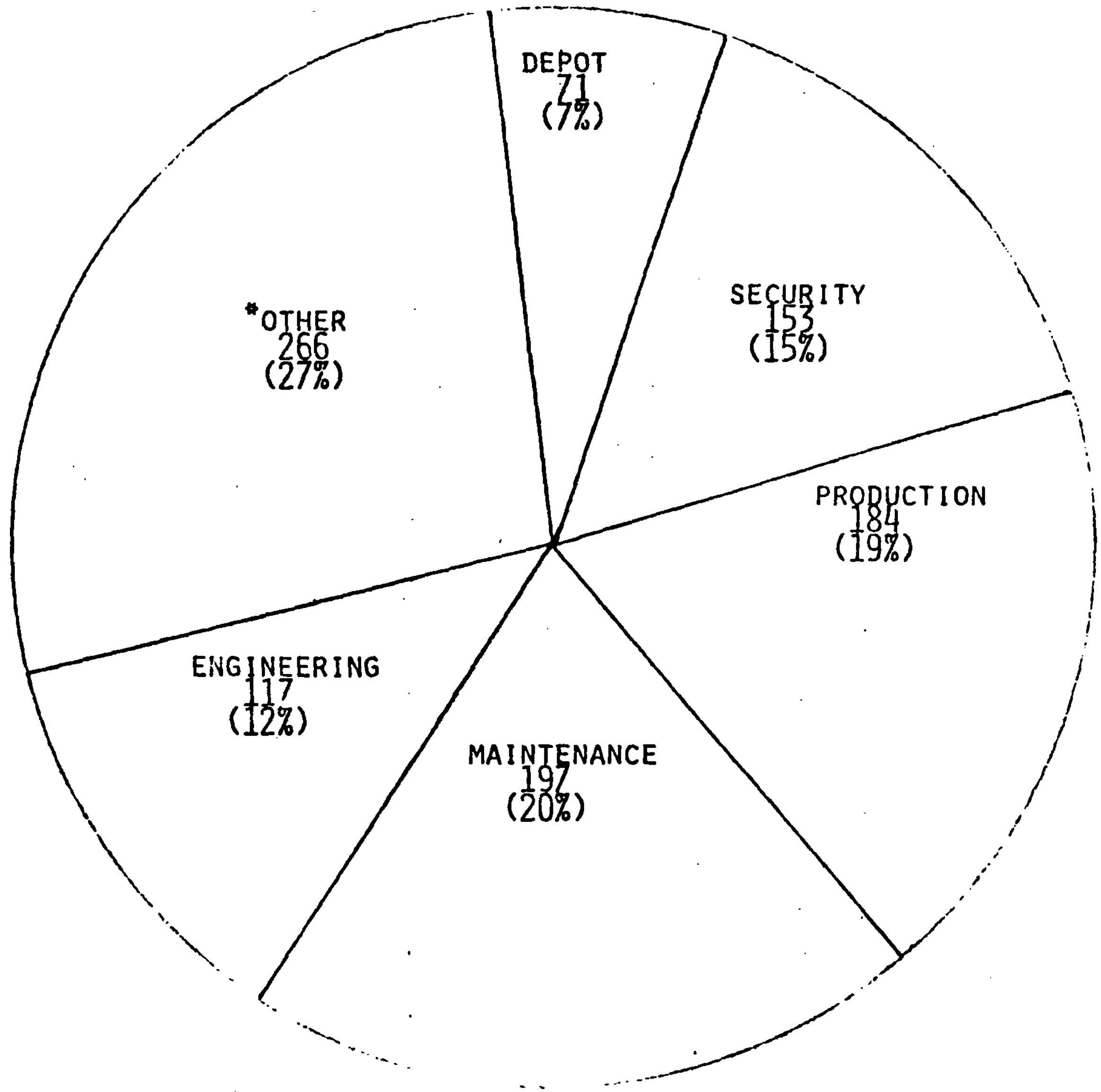
– – – – – – indicates separate elements not having a common chief.

PBA MANPOWER DISTRIBUTION
TDA AUTHORIZED STRENGTH, 988*

* OTHER

PERSONNEL OFFICE
COMPTROLLER
PROCUREMENT
DATA PROCESSING
UTILITIES
FIRE PREVENTION
MOBILE EQUIPMENT & RAIL TRAFFIC
PROPERTY





*INCLUDES AUTHORIZED OVERSTRENGTH 76

INSTALLATION ASSESSMENT OF PINE BLUFF ARSENAL

RECORDS EVALUATION REPORT NO. 113

The following information is recommended for inclusion in the subject report to provide a single-source document showing past, present and future activities addressing the complex problems of environmental pollution and contamination control:

a. Pine Bluff Arsenal Contaminated Areas Project, FY 74-76: Twenty-nine areas suspected to contain contaminated material were located on Pine Bluff Arsenal (Figure II-10). A project began in FY 74 for collecting and analyzing samples from these areas to determine the extent and concentration of the contamination in each area. The samples were collected according to a statistical sampling plan. The sample analyses consisted of both chemical and biological. The methods for chemical analyses are reported in Edgewood Arsenal Contractor Report, EC-CR-76064, Methods for Analysis of Contaminated Soil, Pine Bluff Arsenal, Pine Bluff, Arkansas, March 1976, by Aubrey B. Gosnell, GO CHEM, Inc., 2075 Elaine Circle, Arkadelphia, Arkansas, Contract No. DAAA15-75-C-0183, Department of the Army, Edgewood Arsenal, ATTN: SAREA-CL-DC (Dr. Emory W. Sarver, Project Officer, 671-3129), Aberdeen Proving Ground, Maryland 21010.

Chemical analyses data is stored at the North East Computer Center, Fort Monmouth, New Jersey, with DDT analyses by isomer stored at the Chemical Systems Laboratory (CSL), Aberdeen Proving Ground, Maryland, in the UNIVAC 1108 system.

All data is scheduled for conversion and entry into the Installation Restoration (IR) data management system at CSL, during FY 78. Information on IR data collection and retrieval for evaluation can be obtained from Department of the Army, Office of the Project Manager for Chemical Demilitarization and Installation Restoration, ATTN: DRCPM-DRR (Mr. Shatto), Aberdeen Proving Ground, MD 21010.

b. Department of the Army, Army Materiel Command, Armament Command, Installation-Wide Environmental Impact Assessment for Pine Bluff Arsenal, 11 September 1975, can be obtained from: Commander, Pine Bluff Arsenal, ATTN: SARPB-ETC, Pine Bluff, AR 71611. The document describes the current discharge of pollutants to the environment which will continue through 1979 when new pollution abatement facilites will be completed. The streams and sites now receiving this discharge will be the most recent addition of pollutants which will need to be considered under any cleanup program.

c. An Analytical Systems Committee was established by the Project Manager for Chemical Demilitarization and Installation Restoration in September 1975 with the following mission:

(1) Review state-of-the-art methodology for analyzing known or suspected contaminants at RMA and at other installations requiring subsequent survey; determine knowledge gaps in analytical technology which need to be addressed by research, modification, and verification efforts; and recommend to the Program Manager for Installation Restoration (PMIR) programs, outlining time/cost/manpower requirements, to fill these knowledge gaps.

(2) Integrate the overall technical efforts of the several agencies involved in analytical technology.

(3) Monitor approved and funded analytical technology programs to assure that analytical procedures and equipment used for defining the contamination profile (before and after decontamination) are acceptable from the standpoint of economics, speed, precision, accuracy, and reproducibility, and assure that such programs are in compliance with statuatory and regulatory requirements.

(4) Insure the development and administration of an extensive quality control program which will insure reliable analytical results.

Draft copies of approved methods concerning the analytical requirements for the Installation Restoration Program at Pine Bluff Arsenal can be obtained from this committee at Project Manager for Chemical Demilitarization and Installation Restoration, ATTN: DRCPM-DRR, Aberdeen Proving, MD 21010.

d. Standing Operating Procedure Number 74-21, Spill Reaction Plan for Oil and Hazardous Substances, 18 Apr 75. A copy of this report can be obtained from: Commander, Pine Bluff Arsenal, ATTN: SARPB-FAE, Pine Bluff, AR 71611.

e. Standing Operating Procedure Number 71-9, Preparation of Plans and Projects - Natural Resources, Land, Forest and Wildlife Management, Roads and Railroads, 30 Oct 74. A copy of this report can be obtained from: Commander, Pine Bluff Arsenal, ATTN: SARPB-FAE, Pine Bluff, AR 71611.

f. Summary of Public Laws Related to Pollution Abatement: The first public law (PL 92-500) relates to traditional water quality parameters such as pH, suspended solids, biochemical oxygen demand and oil and grease with a statement on toxic substances which is the basis for an early study on potential contaminated areas. This public law will be met in 1979 through on-going construction.

The second public law (PL 95-95) deals with air quality which, like the initial public law, will be met in 1979 through ongoing construction.

The third public law, 92-500, 40CFR, part 129, Toxic Pollutant Effluent Standards, applies to our current DDT problem with rules published in the Federal Register on 12 Jan 1977 stating that DDT will cease to be discharged (zero, i.e., 10 parts per trillion) by 12 Jan 1978. Additional rule making under this act will likely continue and may include up to 165 new chemicals by 1983.

The last two public laws are new and PBA is attempting to understand these public laws as they apply to Pine Bluff Arsenal by requesting funds for study, design, alteration, or construction of new facilities to meet these criteria.

There have been a total of four public laws passed by Congress to date which apply to pollution abatement efforts at Pine Bluff Arsenal and are listed as follows:

(1) The Federal Water Pollution Control Act of 1970, as amended 1972, PL 92-500 (NPDES Permit)

(2) Clean Air Act Amendments 1977 - PL 95-95

(3) The Federal Water Pollution Control Act of 1970, as amended 1972, PL 92-500, 40CFR, Part 129, Toxic Pollutant Effluent Standards (DDT)

(4) The Toxic Substances Act - PL 94-469

(5) Solid Waste Disposal Act - PL 94-580

g. DDT Containment Project: The survey (1a, above) indicated that DDT, heavy metals and Phosphorus were the major problems at PBA.

Since DDT was the major problem, a program was initiated in late 1975 and completed in 1977 to reduce the level of migration of DDT off-post using the existing standards in the literature. Blue gill fish were used as the test organism for aquatic life and the goal of the project was to not exceed the concentration of 0.05 of the 96 hour TLM_{50}. To accomplish this task, White Creek was diverted around the landfill in the south area and Triplett Creek in the north area was diverted upstream away from the major contaminated areas. In the south area, the old landfill was resealed with clay, covered with topsoil and reseeded with grass. In the north area, large areas of ground were covered with crystalline DDT up to five inches thick around the old production buildings and had washed into Triplett Creek and contaminated the creek the full length and into the Arkansas River. In the north area after stream diversion, retention basins were constructed prior to pickup and burial of DDT in three areas to avoid a high discharge of DDT into the Arkansas River during the rainy season which was concurrent with the cleanup effort. The areas were sealed with clay, covered with topsoil and reseeded with grass. No attempt was made to clean up the same ten miles of stream bed which make up both creeks since this would have been very costly and was not required to meet the 96 hour TLM_{50} for blue gill fish. In brief, once the source had been eliminated, natural silting would have sealed the streams to the extent the test criteria could be met. The above tasks in both the north and south areas are complete and were accomplished with Arsenal technical staff and lab.

h. Public Law 92-500, 40CFR, part 129 (DDT - Zero Discharge): Pine Bluff's most immediate problem is Public Law 92-500, 40CFR, part 129, which limits discharge to zero by 12 Jan 1978. Due to the complex nature of a problem dealing with such low levels of discharge (10 parts per trillion), that is one drop in 13,000 gallons, two contractors were retained to establish various engineering alternatives and their cost to meet the standard and to identify the level of DDT in the environment around and entering Pine Bluff Arsenal. These low levels were suspected of being in the area since DDT had been used by the private sector for many years. These studies will be completed in early December 1977 with some decision as to a course of action being developed and forwarded to EPA. Preliminary background studies have been accomplished by PBA which indicate that rain water contains 325 parts per trillion (ppt), the Arkansas River both up- and downstream, 189 ppt, and sediment in the river both up- and downstream approaching 1 million parts per trillion. DDT is soluble in water at 3,000 ppt with sediment continually mixing with water on occasion to allow the water to reach this level. The initial PBA task was to deny this contact between water and sediment containing crystalline DDT.

i. Ecology Program: An overall PBA Ecological Program is being developed under contract with Battelle-Columbus Labs to insure that future discharge from active production sources does not continue to impact on the environment. Program outline may be obtained from Commander, Pine Bluff Arsenal, ATTN: SARPB-ETD, Pine Bluff, AR 71611.

j. Installation Restoration Program: In early 1976, the Army assigned a program manager to help installations such as Pine Bluff Arsenal, with migration problems (from inactive production sites) at the boundary/off-post interface for both surface and subsurface. Currently, a preliminary investigation of the contaminant situation covering all materials identified in the initial survey is in progress. This initial program will be completed during 1978 with recommendations being available after that time. Information on this program can be obtained from the Project Manager for Chemical Demilitarization and Installation Restoration, Aberdeen Proving Ground, MD 21010.

k. PBA Supplement 1 to AMCR 11-5 - Environmental Enhancement and Pollution Abatement: The document provides a list of Environmental Impact Assessments, Pollution Guidelines for Directors of various operational units and examples of actions requiring coordination with the PBA Environmental Coordinator.

l. <u>Contract for Use of PBA Facility to Manufacture DDT by Private Contractor</u>: Efforts should continue to locate contracts thought to be in CE files in either Fort Worth or Little Rock. Records have not been found at PBA.

m. <u>Interviews</u>: Efforts should be made to interview the following people:

(1) COL Lovelady: office phone - (501) 378-6213
home phone - - [redacted]
Little Rock, AR
Job: Production Foreman in DDT Plant

(2) Dr. William Trigg - Arkansas Tech, Russellville, AR
Department of Chemistry
Job: Haul waste to pits from DDT Plant

(3) Mr. Hickerson - Altheimer, AR
Job: Haul waste to pits from DDT Plant

n. Phosgene was stored in TSY. Also, demil and transfer operations occurred here.

o. GB, VX were never held in TSY but were stored in igloos in ammunition storage areas.

p. Mustard shells have been found in area along Arkansas River in area noted 1 in II-14.

q. Building 53-990 was leased to a paper bag company during the 1950's and 60's.

r. Building 50-510 was leased to an ink manufacturer in early 1960's.

APPENDIX U

INSTALLATION RESTORATION ACCOMPLISHMENTS AS OF OCT 79

APPENDIX U

INSTALLATION RESTORATION ACCOMPLISHMENTS

AS OF OCT 79

The records research program documented in this report was the first step in identifying probable areas of contamination at PBA. Since this report identified a number of contaminated sites, programs were initiated to (a) develop a contamination profile in groundwater, surface water, soil and sediment, and (b) to develop and implement corrective measures to prevent actual or potential off-post contaminant migration. A brief discussion of each follows:

a. Contaminant Profile. Thousands of samples have been collected and analyzed from groundwater, surface water, soils and sediments. The results are being entered into an Installation Restoration data base. Preliminary checks indicated that there is no off-post migration of contaminants in excess of EPA standards, that there are currently high levels of chlorides and sulfates in some on-post groundwater monitoring wells, and that there is nonmigrating contaminated soil present on the installation. All scheduled sampling and analysis activities required to complete the installation contamination profile were completed in September 1979. During FY80, a comprehensive analysis will be made of the types, locations and concentrations of each contaminant. Specific attention will be given to any results indicating that a compound(s) is in excess of EPA standards, and to those with migratory potential, (i.e., present in water or sediment).

b. Migration Containment. Preliminary surveys indicated that DDT and arsenic were being carried in the sediment of Phillips Creek and White Creek toward the Arkansas River. To correct the problem, the following actions were taken:

(1) In the southern part of the Arsenal, where DDT had been dumped in an old landfill, a stream (White Creek) was diverted around the landfill, and the landfill itself was covered with clay, compacted, surfaced, sloped, topped with fertile soil, grassed over, fenced off and posted with protective signs.

(2) In the northern part of the Arsenal, where the DDT had been manufactured, more extensive preparatory measures were necessary. Three sediment retention basins were constructed, each downslope from a major DDT deposit. A small tributary of Triplett Creek, upstream of the deposits, was diverted some 800 feet to a neighboring tributary to reduce the scope-requirement for the third basin. Then the crystalline DDT material was scooped up and placed in the hydraulically-sealed foundations (basements)

of previously razed buildings located nearby. Finally, these DDT-filled basements were sealed off with clay, and otherwise treated like the landfill in the south. While the basements were large enough to accept the crystalline and concentrated DDT material, a large volume of contaminated soil was also loosened by the scooping and grading. This contaminated dirt was gathered onto the property adjacent to the old manufacturing site and there covered with clay, in the manner of the other sites.

(3) White and Phillips Creeks are monitored monthly. The actions described above have been effective in preventing any further off-post migration. Although greatly reduced, some contaminated sediment is still moving slowly down Phillips Creek. To stop all remaining migration, 3 additional basins have been designed and an MCA request for funds submitted to permit construction in FY82.

A complete final report documenting the results of the contamination survey and the corrective measures taken to eliminate DDT and arsenic migration problems will be prepared by April 1980.

PRE-SCORE

REFERENCE 5

US Army Corps
of Engineers
Tulsa District

PINE BLUFF ARSENAL

HAZARDOUS LANDFILL/
CLOSURE SITES

PN: 83 FY: 86

CONCEPT DESIGN ANALYSIS

VOLUME 2 — ATTACHMENTS A THRU F

AUGUST 1984

PINE BLUFF ARSENAL
ARKANSAS

CONCEPT DESIGN ANALYSIS
HAZARDOUS LANDFILL/CLOSURE SITES
PN: 83 FY: 86

VOLUME 2
ATTACHMENTS A THRU F

AUGUST 1984

DEPARTMENT OF THE ARMY
TULSA DISTRICT, CORPS OF ENGINEERS
OKLAHOMA

permeability, and pervasiveness of the natural clay stratum that will be serving as the lower boundary and depth to water table and gradient. Borrow materials for low permeability cutoff or slurry trenches and a clay cover chemically resistant to materials encapsulated are also required.

4. Site Discussions

INTRODUCTION

Results of geotechnical investigations are presented in the following site discussions. Discussions of site 10A and 20A represent the results of detailed investigations at these sites. Investigations at these sites have been completed with exception of drilling beneath the final dike alignment on site 20A to confirm the existence and determine the depth to the top of the clay stratum which forms the lower boundary in an encapsulation scheme. Discussions of the remainder of the sites represent the results of the preliminary phase of investigations.

SITE 2, WEBSTER ROAD TEST SITE

1. Site Description. The Webster Road Test Site is an abandoned test site for DM, CN, and manganese grenades. DM, also known as adamsite, is an arsenic-based vomiting agent. CN is tear gas. The site is located on Webster Road near the intersection with McCoy Road and is just south of the BZ demilitarization facility currently under construction. The location is shown on the vicinity map, plate X-1, and site plan, plate X-2. The

site, at approximate elevation 236, is very small and covers less than ¼ acre. Burning appears to have been confined to a small portion of the site.

2. Investigations. The site was investigated with nine 5-foot and one 40-foot auger holes. Also, good geologic information was available from the BZ/Munitions Disposal Facility site investigation, just to the northwest of the site. Although groundwater monitoring was not required at Site 2, an old AEHA monitoring well exists approximately 50 feet from the burn pile. Boring locations are shown on the plan of explorations, plate X-2.

3. Results.

a. Contamination. Contaminants found at Site 2 include lead, zinc, mercury, barium and arsenic. The toxic contaminants, lead, arsenic, and mercury were found above background levels in only 3 holes,(1, 2, and 10). Values of contaminants in the burn material were arsenic: 300-700 mg/kg, mercury: 96 mg/kg, and lead: 80-400 mg/kg. Holes 1, 2, and 10 encountered burn material and contaminated soil. The maximum depth to which contamination was detected was 6 feet. Hole 8 encountered 6 inches of a possible burn material but only elevated levels of zinc were found. About 100 cubic yards of contaminated material are estimated to exist at Site 2. Results of the EP toxicity tests show the material to be a non-RCRA waste.

b. Stratigraphy. The Jackson Group was found in the borings near site 2, including core holes on the runoff control project, monitoring wells for the North Oxidation Pond, and auger holes for the BZ project. However, the Jackson could not be recognized in the 40-foot hole drilled at site 2. At least the upper 10 to 20 feet at the site consist of terrace deposits. The clays are all low plasticity and contain 30 to 40 percent sand. Liquid limits are all under 27.

The permanent water table is about elevation 200

SITE 4A, 504TH STREET BURNING SITE

2. Investigations. Seventeen auger holes from 5 to 40 feet deep were drilled at Site 4A. The auger could not penetrate the metal in the northeastern portion of the site and it was necessary to use a backhoe to remove the burned material. Nine backhoe pits were excavated. Four of the pits were deepened by augering and 5 of the pits explored the deep fill area near the pond. All borings are shown on the plan of exploration, plate X-3.

3. Results.

a. Contamination. All of the burn material samples tested show high levels of lead (100 to 300 mg/kg), zinc (400 to 2700 mg) and barium (180-7400 mg/kg). However, zinc is not a RCRA listed toxic metal. This material varied from 1 to 4 feet in thickness. None of the soil samples below the burn material, however, show any contamination. About 7500 cubic yards of burned material is estimated to exist at the site. The filled-in pit beneath the pond contains mostly rubble mixed with some gray-colored soil and covered with about 1 foot of soil. This material was not sampled for testing. About 4000 yards of rubble is estimated to exist beneath the ponded water. Three open areas exist northeast of the burn area. These areas have no vegetation and were explored by holes 14 to 17. Laboratory results show that they are not contaminated. Approximately 12,000 cubic yards of contaminated materials and rubble exist at Site 4A. Results of EP toxicity tests shown the material to be non-RCRA waste. Although the groundwater has not been sampled at Site 4A, one water sample from the pond and 2 from the stream flowing out of the pond have been tested and contain

0.06 to 0.08 mg/l arsenic and 0.04 to 0.06 mg/l lead. The drinking water standard for both of these contaminants is 0.05 mg/L.

b. Stratigraphy. Site 4A rests on residual overburden developed on the Jackson clay-shale. The top of the clay-shale varied in depth from 1 foot in boring 17 to 16 feet in boring 1. In most borings (including boring 1) a low plasticity clay extends from the top of the Jackson to the ground surface (or base of the burn material). As shown on the geologic section, several borings have some silt and clayey sand above the Jackson, especially holes 5 and 12. A geologic section for Site 4A is presented in plate X-3.

c. Water Table. The permanent water table is about elevation 270 and slopes steeply to the north. Perched water is found in several of the holes between 0 and 2 feet in depth.

SITE 7A DEPOT STORAGE YARD

1. Site Description. The Depot Storage Yard is a 40-acre storage site which has been used since 1949 to store pesticides, CS, FS, and various decon agents. Most of these agents have been removed but approximately 11,000 drums of FS, several thousand pounds of CS, and several cans of DS 2 still remain. The CS and DS 2 are to be removed, but the FS, which is a corrosive screen smoke, belongs to the Navy Department and will not be removed. Building 55-320 on the east end of the Depot Storage Yard is used to rennovate one-ton bulk containers of blister agents. An abandoned concrete tank and pile of debris which emits irritating fumes is present southeast of the building, inside the fence. The tank, debris, and any

contaminated soil will be removed and the rest of the yard will remain active as a non-toxic storage facility. Runon/runoff control will be provided for the entire 40-acre site.

2. Investigations. No investigations have been performed inside the TSY fence, although extensive explorations have been performed just south of the fence at sites 7B, Demilitarized Lewsite Sludge Disposal Area, 7C, Mustard Agent Burning Yard, and 7D, DSY Borrow Pits. In addition, seventeen 10-foot auger boring were drilled around the west, north and east sides of the DSY fence in drainages which left the Depot Storage Yard. Fourteen groundwater monitoring wells were installed in and around the DSY by Waterways Experiment Station and the Corps of Engineers, and geologic information is available from those. All well and boring locations are shown on plate X-4.

3. Results.

a. Contamination. The drainages leaving the DSY to the north, west, and east do not show contamination with the exception of the very southeast corner of the yard in the vicinity of the debris behind the bulk container-rennovation building. Elevated levels of arsenic and mercury were detected in the soil in these drainages and in the drainages from the south side of the yard.

b. Geology. Borings drilled just south of the yard indicate that the yard rests on terrace deposits of sand, silt, and clay. These deposits are about 15 feet thick on the west and 45 feet thick on the east. Clay-shale of the Jackson Group underlies the terrace deposits. The permanent water table beneath the Depost Storage Yard is approximately 20 feet below ground surface and slopes radially to the north, east and south. Perched water likely occurs in the terrace deposits.

SITE 7B, DEMILITARIZED LEWISITE SLUDGE DISPOSAL AREA

1. Site Description. Site 7B, an abandoned demilitarized sludge lewisite disposal area, consists of an unlined 4-acre drained lagoon adjacent to a small creek, a tributary to Phillips Creek. A white limy sludge measures as deep as 7 feet in some places in the old lagoon. Some of this material has been transported downstream and is found in the banks and in the bed of the small creek. The white sludge is demilitarized lewisite sludge. Lewisite, a chlorinated arsenic blistering agent, was rendered inert by treatment with supertropical bleach, a lime compound with 30% available chlorine. The site lies between the elevations of 244 and 250. Drainage is to the south and east. Vegetation is nonexistent or severely distressed in the drained lagoon area and in the streambed 500 feet downstream of the site. Runoff from the site will enter the surface impoundment once the FY83 Runoff Control Project is complete.

2. Investigations. Four monitoring wells, 62, 128, 129, and 130 have been installed in the vicinity of Site 7B. Eighty-seven shallow auger holes varying in depth from 3 to 22 feet have been drilled at the site. The holes are located around the perimeter of the site and through the sludge into the soil beneath the site. Additional holes were drilled in the stream adjacent to and downstream of the site to the axis of the Runoff Control embankment.

The shallow holes were drilled for the purpose of establishing the thickness of the sludge and obtaining soil samples for determining the depth of contamination. Two 40 foot core holes (103 and 104) were drilled, for the purpose of establishing the geology of the area. All well and boring locations are shown on plate X-4.

3. Results.

a. Contamination.

(1) General. The major RCRA-listed contaminants at Site 7B are arsenic and mercury, which are found in the demilitarized lewisite sludge and in the soil beneath the sludge. This sludge has a pH of 11.5 to 12.8, arsenic concentrations as high as 13,000 mg/kg and mercury concentrations as high as 4,440 mg/kg. Mercury was used as a catalyst in the lewisite manufacturing process and was disposed of along with the demilitarized lewisite. The soil beneath the demilitarized lewisite is contaminated to an average depth of 3 feet with arsenic concentrations as high as 1,300 mg/kg and mercury concentrations as high as 17,000 mg/kg. Several of the borings adjacent to, but outside the demilitarized lewisite sludge area show contamination in the upper 1 to 2 feet, and some show no contamination at all. EP toxicity tests were performed on samples of the sludge and underlying soil. The sludge did not exceed the RCRA limits (probably because of its high initial pH), but the soil beneath the demilitarized lewisite sludge contained both mercury and arsenic above the RCRA limits.

(2) Volumes. The sludge is present over approximately 4 acres, and is as deep as 7 feet in places. An estimated volume of 23,000 cubic yards of the demilitarized lewisite sludge remains at the site. An estimated 20,000 cubic yards of contaminated soil is present beneath the sludge. Another 8,300 cubic yards of contaminated soil is present in the streambed in the first 3,000 feet downstream of the site An isopach of contaminated soil at Sites 7B, 7C, and 7D is presented in plate X-5.

(3) Groundwater. The water table is at approximate elevation 240 over most of the site. It generaly conforms to the surface topography, sloping toward the south and east. The gradient is approximately 20 feet per mile. The stream draining the lewisite area intersects the water table and groundwater occurs in the demilitarized lewisite sludge. Groundwater contamination data from the monitoring wells, which are not located inside the actual disposal area at the site, does not indicate groundwater contamination with arsenic or mercury. Well 62, which is upgradient to Site 7B, had arsenic, barium, chromium, lead, mercury, and selenium detected at least once during the first five sampling rounds. Drinking water standards were exceeded on arsenic, lead, and selenium at least once in this upgradient well. The downgradient wells, 128, 129, and 130 had minor amounts of all 8 RCRA listed toxic metals in at least one well sometime during the sampling period. The drinking water standards were exceeded at least once for lead in all three wells and for selenium in wells 128 and 129. It appears that the contamination found in the ground water both upgradient and downgradient of the site is part of the overall contamination of the area and not resulting from the demilitarized lewisite sludge and mercury disposal operations. However, groundwater flowing through the

demilitarized lewisite sludge may be carrying contamination in a localized area within the streambed downstream of the site.

b. Stratigraphy. Site 7B rests on terrace deposits of sand, silt, and clay. Low plasticity clay, with liquid limits of 30 to 40, is 5 to 10 feet thick beneath the demilitarized lewisite. Clay-shale is about 8 feet deep at the western edge of the site and drops off to about 25 feet deep at the eastern end. The clay-shale is interbedded with uncemented to weakly cemented sandstone and is probably similar to the clay-shale encountered at the FY83 landfill. Geology is shown on sections B-B to D-D, plates X-6 and X-7.

SITE 7C, MUSTARD AGENT BURNING YARD

1. Site Description. The Mustard Agent Burning Yard is located on the banks of a small intermittent creek, a tributary to Phillips Creek. The 1/2 acre site is covered by a layer of ash and demilitarized mustard residue. The materials emit irritating fumes. Laboratory analysis of the residue indicates a pH of 0.5 to 1.2 and elevated levels of arsenic, mercury, and lead. A limited amount of mustard still exists at this site. The site is flat at approximate elevation 251. There is no vegetation in the area where a visible ash residue exists. Vegetation grows with no evident distress outside the burn area. Drainage is to the west in a channel located just north of the site. An abandoned contaminated sewer entered this drainage just north of the pile of mustard residue. The sewer line carried contaminated material from the bulk container-rennovation building at the east end of the DSY, during the period of time when mustard and sodium

arsenite containers were rennovated. Runoff from the site will enter the surface impoundment once the FY83 Runoff Control Project is complete.

2. Investigations. Four monitoring wells, 132-135 were installed around site 7C. Wells 132 and 135 are upgradient to the site and wells 133 and 134 are downgradient to the site. One 20-foot and two 10-foot deep auger holes were drilled through the mustard residue. Eighteen shallower auger holes were drilled in the edges and around the outside of the obvious mustard residue and ash in the drainage to the north and west of the site, and in areas of apparent contamination in the vicinity of the site. One 60 foot auger hole was drilled just east of the site to establish geologic conditions. A sediment sample was taken from the mustard residue pile. Sediment samples 13, 14, 15 and a water sample were taken from the areas where runoff from the Depot Storage Yard enters the 7C area from culverts. All boring locations, well locations, and sample loations are shown on plate X-4.

3. Results.

a. Contamination.

(1) Demilitarized Mustard Pile. Low concentration of mustard were found from depths of 1 to 4 feet in boring 3 through the middle of the demilitarized mustard pile. Pine Bluff Arsenal's Technical Escort personnel conducted a drilling and sampling operation around this hole in order to define the area containing mustard. Results of this investigation are not yet available. A conservative estimate of the quantity of material

containing mustard is 175 cubic yards. The only heavy metals in the samples near those containing mustard are lead, arsenic, and mercury. Arsenic and mercury are not found as deep as the mustard, but lead is present in concentrations of 20-40 mkg/kg some 4 feet below the mustard residue. A sample from the mustard pile had 120mg/kg arsenic and 35 mg/kg lead. The samples were tested for sulfur at a commercial lab, because sulfur is present in mustard byproducts and should be a good indicator of mustard byproducts. The residue was nearly 90% sulfur and the percentage decreased to background levels with depth. An estimated volume of 900 cubic yards of mustard residue and soil with elevated concentrations of lead are present in and beneath the mustard burn pile An isopach of contaminated soil at Sites 7B, 7C, and 7D is presented in plate X-5.

(2) Area North and Northwest of Demilitarized Mustard Pile. Concentrations of arsenic above background levels (10-600 mg/kg) and mercury (2.0-500 mg/kg) were found in the holes located in the drainage northwest of the mustard residue pile to the maximum depth of the holes as well as in the vicinity of the southeast corner of the DSY fence. An estimated volume of 11,000 cubic yards of soil contaminated with arsenic and mercury are present in this area. The high values of arsenic in well 135 suggest that contamination is present to some depth. The source of arsenic and mercury in the soil and groundwater is probably the contaminated sewer from the bulk container rennovation process inside the DSY.

(3) Groundwater. The water table is at approximate elevation 240 over most of the site. It generally conforms to surface topography, sloping toward the south and west. The gradient is approximately 20 feet per mile.

All four monitoring wells in the vicinity of site 7C have shown lead and/or arsenic in concentrations above the drinking water standards. Table 1 summarizes the contaminants in excess of the National Interim Primary Drinking Water Regulation (NIPDWR) Standards.

TABLE 1

SITE 7C-SUMMARY OF CONTAMINANTS IN EXCESS OF NIPDWR* STANDARD

Concentration in Milligrams/Liter

Well #	Date	Arsenic	Cadmium	Lead	Selenium	Silver
NIPDWR Standard		.05	.01	.05	.01	.05
132	28 Jan 82				.024	
132	14 Apr 82				.033	
132	29 Jun 82				.040	
132	7 Sep 82	.066			.037	
133	28 Jan 82		.012			
133	14 Apr 82	.490		.08	.021	
133	29 Jun 82	.083				
133	7 Sep 82	.270		.06		
133	12 Jan 83	.059		.07		
134	21 Apr 82			.07		
135	27 Jan 82	.82				
135	28 Jan 82	3.31				
135	30 Mar 82	15.6		.07		.06
135	13 Apr 82	22.7		.07	.048	
135	3 Jun 82	8.6				
135	7 Sep 82	20.6		.098	.045	
135	1 Dec 82	21.2		.07		

* National Interim Primary Drinking Water Regulation

Well 135 has an average concentration for arsenic of 13.1 mg/l, which is 250 times the drinking water standard. Groundwater contamination does exist in the vicinity of site 7C. The high concentrations of arsenic in well 135 suggests that the arsenic contamination is coming from the contaminated sewer outfall in the drainage north of the actual mustard residue pile.

EP Toxicity Tests. EP toxicity tests were performed on residue and soil samples from the demilitarized mustard burn pile and a soil sample from the drainage. All heavy metals contents were below RCRA limits.

b. Stratigraphy. Site 7C rests on terrace deposits of sand, silt and clay. A silt layer from 1 to 3 feet thick is present directly beneath the mustard burn pile. A low to medium plasticity clay layer at least 6 feet thick and as much as 11 feet thick underlies the thin silt layer. Liquid limits of the clays very from 30 to 55. Sands and silts underlie the clay stratum. Clay-shale of the Jackson formation is 42 feet deep beneath the ground surface. Geology in the area is shown on section GG which is located on plate X-8.

SITE 7D-DSY BORROW PITS

1. Site Description. The Depot Storage Yard borrow pits consist of 2 pits and surrounding area as shown on drawing X-4. These water-filled pits are about 50 feet wide and 400 feet long and are located south of the DSY fence between Sites 7B and 7C. The borrow pits were a source of material in the construction of the DSY. Some runoff from the DSY is collected by the pits. During and after the second world war, mustard and lewisite munitions were buried in five pits just east of the northern borrow pits. In 1955, these munitions were exhumed and demilitarized, and soil graded back in place. Deep contamination, strong organic odors, and buried demilitarized mustard rounds remain in this area. The elevation of the ground surface around the pits is about 242, and the water surface is 241.8, which is at or very close to the permanent water table. Vegetation does not grow in the

flat areas to the east and west of the pits. The pits are connected during periods of high water. Runoff from this area will be within the FY83 runoff control project.

2. Investigations. Four monitoring wells have been installed in the vicinity of site 7D (129, 130, 131, and 64). Fifteen holes, 5 to 25 feet deep were drilled around and to the east of the borrow pits and one 40 foot auger hole was drilled to establish geologic conditions. Sediment samples have been taken from the borrow pits in 4 locations. Sediment samples were also taken from a culvert draining from the DSY into the 7D area. Water samples have been analyzed from both borrow pits. All sampling locations are shown on plate X-4.

3. Results.

a. Soil Contamination. Two separate areas of contamination have been identified: one east of the borrow pits in the vicinity of the old mustard and lewisite disposal trenches and one on the north shore of the northern-most borrow pit. The major RCRA listed comtaminants in both contaminated areas at site 7D are arsenic and mercury. The source of these contaminants on the north shore of the northern borrow pit is not known, but must have come from nearby undocumented operations. In the area east of the borrow pits, arsenic is present above background concentrations and as high as 280 mg/kg to a depth of 7 feet in hole 93, greater than 5 feet in hole 89 and greater than 10 feet in hole 90. Mercury is present in concentrations as high as 300 mg/kg to a depth greater than 10 feet in hole 90. Hole 106 is north of the borrow pits in an area where a strong chemical odor is present and has arsenic in concentrations as high as 500 mg/kg to a depth of at least 5 feet. Sediment samples from a drainage leading into the area were tested and found to have concentrations of 44 mg/kg arsenic, 123 mg/kg lead, and 87 mg/kg chromium. An estimated volume of 35,000 cubic yards of contaminated soil is present east of the borrow pits and 100 cubic yards of contaminated soil is present north of the northern borrow pit. An isopach of contaminated soil at Sites 7B, 7C, and 7D is presented in plate X-5..

b. Sediment in Borrow Pits. Four sediment samples from the borrow pits were analyzed (SD-1, 108, 109, 110). None of the heavy metal concentrations were above background levels. Results of a gas chromatograph-mass spectrometer scan on a semiment sample found no organic compounds, other than a trace of dibutyl phthalate, a common plasticizer.

c. Water in Borrow Pits. A water sample was taken from the east end of each borrow pit and analyzed. No heavy metals were present in excess of drinking water standards.

d. EP Toxicity Tests. EP toxicity tests were performed on several samples and are below RCRA limits.

e. Groundwater. The water table is at approximate elevation 240 over most of the site. The gradient in the immediate area is toward the trenches from the north, east, and west and away from the trenches toward the stream to the south. The gradient is approximately 20 feet per mile. Groundwater contamination in the wells around Site 7D is minor. Unfortunately, none of the wells are truly downgradient of Site 7D. Table 2 summarizes the trenches are about 10 feet deep and the waste piles below the trenches are at approximate elevation 225. The permanent water table is at elevation 200. Spent casings, disarmed grenades, chemical rocket propellers, and other debris such as wood crates were previously stored on the surface of the site. All surface debris was removed from this site and hauled to an approved off-site hazardous waste landfill as part of an emergency service contract in February, 1984.

2. Investigations.

a. Preliminary. Before current investigations began at Site 10A, 57 shallow borings had been drilled for the 1973-1975 Contaminated Area Survey Project. Soil from these borings was tested for heavy metals, DDT, and other contaminants. In 1981, one upgradient and nine downgradient wells were installed at the site to monitor groundwater around the burn trenches as well as the Bombing Mat. Water from these wells is regularly tested by the Army Environmental Hygiene Agency (AEHA) for selected parameters. None of the soil samples from these preliminary studies were classified in the laboratory, but field identifications of the samples from the monitoring wells were made. The downgradient wells are shown on plate X-9.

b. Auger sampling. Thirty seven auger holes were drilled at the site during the fall of 1983 at locations shown on plate X-9. Two additional holes (holes 1 and 2) were drilled north and west of the bombing mat to establish background heavy metal concentrations. Holes 1 through 8 were drilled 40 feet deep with the remainder generally drilled 3 to 5 feet deep. Soil from the auger holes was described in the field and classified in the laboratory. Each run with the auger was limited to 3 feet. To prevent mixing of materials or sampling material that had pulled off from the wall of the hole, only the interior portion of each sample was used. Material was taken from the entire 3-foot sample, sealed in plastic jars and shipped to the Corps of Engineers, Southwestern Division Laboratory in Dallas where chemical and physical tests were performed. Groundwater was sampled in selected holes and analyzed for heavy metals. If the hole penetrated a clay layer, it was backfilled with grout.

c. Burned fill study. Each of the trenches was carefully inspected for burned material. Piles of burned material were investigated to determine quantities of contaminated material. Piles of soil which were most likely produced in the construction of the trenches were examined as well to determine whether or not they also contained any contaminated material.

3. Analysis.

a. Background level of contaminants. In order to define contamination, a background (natural) concentration for each contaminant was measured. To determine background concentrations, holes 1 and 2 were drilled in a geologically similar area as close to the site as possible but free of site contamination. Soil samples from the two background holes were tested for arsenic, barium, cadmium, chromium, lead, mercury, selenium and silver (the eight RCRA listed toxic metal contaminants). In addition, zinc and total phosphorus concentrations were determined because of their suspected presence at the site, even though they are not RCRA toxic contaminants. The mean concentration and standard deviation were calculated for each contaminant. If data is normally distributed, approximately 95 percent of the data will fall within the mean plus or minus two standard deviations. measured concentrations which fall outside the limits of the 95 percent confidence interval are probably not within the normal range of background values. Concentrations that exceed the upper limit indicate contamination above background levels.

Twenty-five soil samples (17 clay and 8 silt) were tested from the two background holes at Site 10A. Contaminant concentration levels in clay differed very little from those in silt so mean concentrations and standard deviations were calculated using combined clay and silt data. Although this method will effectively identify material contaminated above background levels, the background concentrations were found to be too low for use in determining the practical limits of contamination for removal at Site 10A. Upper limits of the 95 percent confidence interval for background concentrations at Site 10A yielded extremely low levels. Using Site 10A background data to determine contamination would result in the removal of soil that is not considered harmful to the environment. Therefore, only the materials with contaminant concentrations above levels that are considered harmful to the environment will be contained or removed in the closure of Site 10A. These "cleanup limits" are higher than the upper limits of the 95 percent confidence interval for Site 10A background concentrations but are lower than the background values found for the same contaminants in clay at Site 20A, the South Burning Pit on Pine Bluff Arsenal. The results of the upper limit of the 95 percent confidence interval for each contaminant found at Site 10A, and proposed clean-up limit to be used for closing this site are given in table 3.

TABLE 3

BACKGROUND SOIL CHEMISTRY
(All values in mg/kg)

	SITE 10		
Contaminant	Background Mean	Upper Limit of 95% Confidence Interval (1)	Cleanup Limit
Arsenic (As)	3.14	5.92	10
Barium (Ba)	25.4	51.30	140
Cadmium (Cd)	0.5	-	0.5
Chromium (Cr)	5.0	-	5.0
Lead (Pb)	3.28	7.80	20
Mercury (Hg)	0.1	-	0.1
Selenium (Se)	1.07	2.76	2.8
Silver (Ag)	0.5	-	0.5
Zinc (Zn)	4.08	8.34	--(2)
Total Phosphate (TPO_4)	56.22	119.42	--(2)

(1) An upper limit of the 95 percent confidence interval was not calculated for chemicals which were below minimum reported values in the background holes.

(2) Since these contaminants are not RCRA toxic contaminants, cleanup limits are not required.

b. Determining depth of contamination.

(1) Method. The depth of contamination was determined by comparing the measured concentration of contaminants with background levels. The depth to which soil would be contained or removed in the clean up of Site 10A was determined by comparing the measured values of each contaminant with the proposed clean-up values presented in table 3. With the results plotted in this manner, the depth of contamination and the depth of soil to be contained or removed is easily determined.

(2) Procedure for determining laboratory tests. Samples from holes . and 4 were tested for lead, zinc, barium, arsenic, chromium, cadmium, selenium, silver, mercury and total phosphorus. Based on the results, lead and barium were found to be the contaminants which best indicated the limits and severity of contamination and were selected for further testing. Zinc was found to be present in concentrtions above background levels and found to be more mobile than the RCRA toxic heavy metals. EP toxicity tests were performed on a burned debris sample from hole 3 and on a soil sample from hole 13 which had been found to have the highest total ion concentrations of lead and barium. Neither of these test results exceeded the limits for EP toxicity set forth in RCRA. Test results are given in table 4.

TABLE 4

EP TOXICITY RESULTS
(Values in mg/l)

Sample #	Depth	As	Ba	Cd	Cr	Pb	Mg	Se	Ag
(RCRA Limit)	--	5.0	100.0	1.0	5.0	5.0	0.2	1.0	5.0
10.3 Jar 2 (Burned debris)	0.2-1.0	0.001	0.6	0.15	0.01	0.24	0.0001	0.004	0.01
10-13 Jar 1 (soil)	2.0-3.0	0.001	0.5	0.01	0.01	0.10	0.0001	0.004	0.01

(3) Groundwater Contamination. Groundwater encountered at Site 10A belongs to the Jackson/Quaternary aquifer. This aquifer generally yields small amounts of low quality water and is not used for any water supply purpose in the vicinity of the arsenal. Drinking water in the area is supplied from the Sparta Sand which is about 600 feet below the site and is separated from it by low permeability Jackson and upper Claiborne groups.

-ests on groundwater samples from the 10 monitoring wells and from 8 auger ..es have shown no heavy metal contamination above drinking water standards existing in the groundwater.

A study was performed on the monitoring wells in the immediate vicinity of the trenches (monitoring well numbers 141, 142, 143, and 144). Well 144 had a water level approximately one foot higher than the water level in the other wells and was considered the upgradient well. Using a Student's T test, the wells downgradient of well 144 did not show significant increases in specific conductance, pH, total organic carbon, and total organic halogen at the 95 percent confidence interval. Therefore, the trenches and related contamination are not contributing to groundwater contamination in the area.

c. Contamination Results.

(1) Trench Contamination. The majority of the contamination at Site 10A is confined to the bottoms and west ends of the 4 northern most trenches. Burned material and contaminated soil from 2 to 3 feet in thickness was found in all but trench 1 and is also piled at the end of trenches 2, 3 and 5. The deepest soil contamination occurs below the waste pile at the west end of trench 2 for a depth of 5 feet below natural ground. Depths and quantities of contamination at Site 10A were found at locations as indicated in table 5.

Table 5

CONTAMINATED MATERIAL QUANTITIES

Location		Depth Of Contamination	Contaminated Material (Quantity) (1) (yd^3)
Trench 2:	Bottom	2'	270
	sides	6"	190
	burnpile	8'	1,600
Trench 3:	bottom	3'	380
	sides	6"	118
	burnpile	3'	470
Trench 4:	bottom	3'	200
	sides	6"	120
Trench 5:	bottom	2'	240
	sides	6"	150
	burnpile	2'	370
	Total		4,100

(1) Quantities include contaminated soils and debris.

Contaminated material consists of burned debris and the soil underlying and adjacent to the burned debris that has been contaminated by its close association with the debris. Lead is the primary contaminant with the highest concentration being 278.8 mg/kg in hole 34. Barium is present in most holes but concentrations are near background levels. The quantity of contaminated material in the trenches and waste piles is estimated to be 4100 cubic yards.

(2) Surface contamination. Surface contamination outside the trenches and waste piles only occurs in the area between trenches 3 and 4. Hole 7 contained concentrations of lead that were slightly above background levels. The remaining holes showed only small amounts of contaminants at the

surface. The quantity of contaminated surface material was estimated to be ... cubic yards betweem trenches 3 and 4 based on an average surface material depth of 6 inches.

(3) Total amounts of Contamination. The total quantity of contaminated material present at Site 10A is estimated to be 4700 yd^3.

4. Stratigraphic results.

a. General. Site 10A is located on terrace deposits which consist of unconsolidated sands, silts, and clays, and are in excess of 40 feet thick. The geologic section shown on plate X-10 is a north-south section which goes through all 5 of the trenches. The section shows clay, sand, and silt interbedded to a depth of 40 feet. However, there does not appear to be any clay strata suitable for use in an in situ closure scheme.

b. Soil. The clays are generally very lean with an average liquid limit of 28. Some of the clays had liquid limits below 23 and were borderline silts. No high plasticity clays were encountered. Silts were plastic with liquid limits similar to the leanest clays. Sands were uncemented and generally silty or clayey.

c. Groundwater. The groundwater at Site 10A flows in a northeasterly direction with a local gradient of about 10 feet per mile. The water table is at approximate elevation 200, 35 feet below the base of the trenches. Perched water occurs above some of the clay beds.

SITE 10B, BOMBING MAT

Site Description. The Bombing Mat is a 30 acre concrete pad used for testing of various production items. The south end of the mat is a RCRA-permitted solid waste storage facility, currently containing HC smoke mix, incinerator ash, and spent munitions. These items will be transferred to the FY86 hazardous waste landfill when it is completed. Site 10B will remain an active site for temporary storage of solid wastes and production testing. It is to be provided with runon/runoff control.

Site Investigations and Geology. Site explorations for 10A and monitoring wells set around the bombing mat indicate that the mat rests on unconsolidated terrace deposits of sand, silt, and clay. The permanent water table exists approximately 35 feet below the bombing mat. Perched water likely occurs in the terrace deposits.

SITE 12 - OLD MUSTARD DUMP YARD

1. Site Description. Historical use of Site 12 was primarily as a burn and disposal area for mustard munitions. The site is adjacent to the Arkansas River at approximate elevation 218, just below the 100-year flood elevation of 220.3. Site 12 extends 2,200 feet from north to south and covers about 25 acres. Scattered across the site are mounds and trenches which are the result of disposal operations. Four parallel trenches on the southern end of the site contain rusted munitions, residue from burning operations and 55-gallon drums. A larger munition pile exists west of the 4 trenches. Pits on the northern end of the site contain the remains of tubes which held

igniter mix for the munitions. A burn area in the center of the site covers approximately 60,000 square feet. A smaller burn area in the northern portion of the site covers about 10,000 square feet.

2. Investigations. A total of 15 auger holes and 4 monitoring wells have been drilled as shown on plate X-11. Engineering classifications were performed on samples from the monitoring wells and chemical analyses are complete on samples from the auger holes. Eight backhoe test pits were dug through the munitions pile, in the four parallel trenches, and in the northern pits containing rods.

3. Results.

a. Contamination. Contaminants from the site include concentrations of barium to 10,000 mg/kg, lead to 1100 mg/kg, arsenic to 40 mg/kg, chromium to 280 mg/kg, and mustard byproducts. Contaminated materials include burn material about one foot thick, black mustard residue from 5 to 8 feet in hole 2, approximately 2 feet of soil beneath the burn areas, and the discarded munition piles. A total estimated volume of 12,000 cubic yards of contaminated materials exist. The material is a non-RCRA waste as determined by EP toxicity test methods.

b. Stratigraphy. Site 12 is situated on floodplain deposits of silt and clay. As shown on the geologic section on plate X-11, there is a considerable amount of high plasticity clay near the surface over the northern 2/3 of the site. Preliminary investigations indicate that this clay extends from the southern to the northern burn areas. The top of the clay layer is approximately 5 feet below the ground surface. The clay has a liquid limit of 50 to 65 and a plasticity index of 27 to 40 and should have very low permeability.

c. Water Table. The water table is nearly flat at approximate elevation 201, 17 feet below ground surface. There is no evidence of groundwater contamination beneath this area from the results of 2 quarters of groundwater monitoring of wells at this site.

SITE 13A - McCOY ROAD BURNING SITE

1. Site Description. The McCoy Road Burning Site is a 12-acre site located about 1 mile west of the bombing mat on McCoy Road. It was used as a burning site until the late 1960's for pyrotechnic materials, particularly CN, a tear agent. There is a possibility that CS, a more potent tear agent, and DM, an arsenic-based vomiting agent, were burned here as well, but neither has been documented. The site is relatively flat, about elevation 245, and is partially grassed and partially barren. The depression which is shown on the inclosed site plan appears to have been largely filled in, but a small pond remains near the center of the site. Some regrading and covering of the site has apparently taken place.

2. Investigations. This site has been investigated with 15 auger borings, 5 to 40 feet deep, drilled in and around burn areas and drainages as shown on plate X-12. In addition, 60 shallow holes were drilled in 1974 for the Arsenal's Contaminated Area Survey Project.

Results.

a. Contamination. All 8 toxic metals and zinc were tested in 2 borings and in water samples. Barium, lead, and zinc were tested in the remainder of the borings. No contamination above background levels was found in either the soil or the burned material, which varied in thickness from 0.5 feet to 3.5 feet. Lead content was generally less than 10 mg/kg. In order to be certain no areas of contamination were missed, data from the 60 earlier borings was examined. These investigations confirm the lack of contamination at this site. Therefore, no EP toxicity tests are planned. Tear gas contains no toxic metals and some prior cleanup may have previously been performed. An estimated 105,000 square feet (2½ acres) of Site 13A is covered with burn material. No EP toxicity tests are planned. Two near-surface perched water samples were taken from both holes 1 and 2. These results show 0.09 and 0.08 mg/L arsenic and 0.06 and 0.02 mg/L lead respectively. The drinking water standard for both of these contaminants is 0.05 mg/L. The permanent water table was not sampled and the water from the pond has 0.04 mg/lead.

b. Stratigraphy. Site 13A is located on terrace deposits of silty sand and silt in excess of 40 feet in thickness. None of the visual classifications showed any clay in the upper 10 feet.

c. Water Table. At the time of drilling, perched water was found in several of the borings between 0.1 and 2.0 feet. The permanent water table is deeper than 40 feet and slopes gently to the east.

SITE 16A, WHITE PHOSPHORUS LANDFILL

1. Site Description. Site 16A was constructed as a flow-through basin receiving phosphorus laden wastewaters from production areas. White phosphorus is an unstable compound which burns on exposure to the atmosphere. The use of the basin was terminated in 1978 and it has been subsequently covered with soil. The site is at approximate elevation 240. Visible evidence of the landfill is a mound of earth 6 to 8 feet high. Existing topographic mapping does not reflect the presence of this mound. A small stream exists on the east side of the landfill area. The landfill area was originally a depression or ravine before landfill operations began. Vegetation grows with no signs of distress in the area. Observations of strong chemical reactions were made during previous drilling and sampling operations, and spontaneous fires have reportedly occurred at the site.

2. Investigations. Eight preliminary auger borings were performed around the landfill and in the small stream east of the landfill. Because of past reports of spontaneous fires in drill holes, the borings are located just at the edge of the site and do not penetrate the material in the landfill. One of the auger borings was 40 feet deep to establish stratigraphy, and the rest were approximately 10 feet deep. One 2-inch diameter piezometer was installed by the Waterways Experiment Station in 1977 at the northwest edge of the site. Water samples were taken from the stream bordering the site, the deep auger hole at a depth of 36 feet and the WES piezometer at a depth of 37 feet. Locations of the borings and piezometer are shown on plate X-13.

3. Results.

a. Contamination. The primary contaminant at Site 16A is total phosphorus which is not a RCRA toxic contaminant. Concentrations are above 500 mg/kg in holes 1 and 2 to a depth of at least 2 feet. Holes 4 and 6 do not show high total phosphorus concentrations. There are minor amounts of lead and chromium in the upper foot of hole 1. The water sample from the stream had concentrations of lead and barium above drinking water standards. Neither the water sample from the auger hole or the WES piezometer contained contaminants above drinking water standards. EP toxicity tests will not be performed on any of the samples because of low concentrations of RCRA toxic metal contaminants.

b. Stratigraphy. Site 16A overlies terrace deposits in excess of 40 feet thick. The terrace deposits consist of interbedded sands, silts, and clays. The clays are of varible thickness, low plasticity, and are discontinuous. Geologic sections AA and BB are presented on plate X-13.

c. Water Table. The permanent water table at site 16A is at approximate elevation 202, 36 to 38 feet below the ground surface. There is no evidence of a perched water table at this site. There is a very gentle gradient to the northwest.

SITE 17 - PRODUCT ASSURANCE

. Site Description. Site 17 was formerly used for the disposal of refuse, such as expended smoke grenades and pyrotechnical devices. The dump site is located along the shore of Yellow Lake. An erosional escarpment plunges from the general elevation of the test range (242 feet) to the level of the lake (202 feet). A considerable volume of debris has been dumped over the escarpment and into the small ravines which dissect it. The debris extends nearly to the lake margin at the toe of the slope.

2. Investigations. A total of 49 auger borings have been completed at the site in the terrace deposits (at the top of the slope), about midway down the slope, in the floodplain deposits near Yellow Lake and in a suspected small burn area to the south. In addition, 4 monitoring wells were installed in 1981, 3 in the floodplain deposits and one in the terrace deposits. All boring locations are shown on the plan of explorations, plate X-14.

2. Results.

a. Contamination. The primary contaminants at Site 17 are lead with concentrations to 4400 mg/kg and barium with concentrations to 1000 mg/kg, both in the debris. None of the most highly contaminated samples of debris or soil exceeded the RCRA limits for EP toxicity. The debris is a maximum of 4 feet thick, about midway down the slope. Soil is contaminated to an average depth of 2 feet below the base of the debris. One area, in the vicinity of holes 7 and 11 has soil contamination as deep as five feet. Hole shows barium contamination as deep as 6 feet. Estimated volumes of 2000 cubic yards of waste material and 2000 cubic yards of contaminated soil exist on the slope. Another 2000 cubic yards of contaminated soil and burned residue are estimated to be present in isolated dump areas to the west of the main part of the site. The suspected burn area to the south has no contamination.

b. Stratigraphy. Low plasticity clay exists below the burn material at the top of the slope to a depth of about 10 feet. The clay is similar in appearance and origin to the clays at Site 10. The clays are borderline clay/silts and are not of low enough permeability to be of use as a lower boundary in an encapsulation scheme. Low plasticity clays are present at the toe of the slope from a depth of 3 to 7 feet. Geologic sections are presented on plates X-14 to X-16. Although these clays are of a more suitable nature than the terrace deposit silty clays, the thickness of 4 feet is not considered adequate for use as a lower boundary in an encapsulation scheme.

c. Water Table. The water table in the area is at the elevation of Yellow Lake, 201. It is only 2 to 3 feet below ground surface on the toe of Yellow Lake. There is a very gentle gradient to the northeast.

SITE 20A, SOUTH DEPOT BURNING PIT

1. Site description. Site 20A, the Depot South Burning Pit, is located within the Arkansas River flood plan adjacent to a swampy wetland. The site consists of a 5-acre burning pit and adjacent storage area along the eastern

boundary of the arsenal. north of the Pollution Abatement Facilities. The majority of the site is flat, at approximate elevation 212, sloping gently to the northeast toward a lagoon area. The water in the lagoon remains at elevation 202 for most of the year. Vegetation grows, with no apparent distress, on the western part of the site. The eastern part of the site is covered by a pavement-like residue upon which no vegetation grows. From 1941 to 1978 pyrotechnic mixes from smokes, grenades, and other incendiary devices were burned at the site, resulting in a layer of burned fill and rubble greater than 12 feet thick in places. Various wastes including smoke mixes munitions, white phosphorus contaminated materials, solvents, and DS-2 decon fluid were stored on the burned fill and the area adjacent to it. All accumulated containerized materials and surface debris dumped on the site were being hauled to an approved off-site hazardous waste landfill as part of an emergency service contract. This work was completed in February 1984.

2. Investigations

a. Preliminary. Prior to beginning the current investigations at Site 20A, some chemical, soil, and groundwater data was available. Ninety shallow borings. about 20 feet deep, were drilled at the site for the 1973-1975 Contaminated Area Survey Project. The soil, though not classified or described, was tested for some of the heavy metals, pH, and other possible contaminants. In 1981, 3 upgradient and 4 downgradient monitoring wells were installed at Site 20A. Material from these wells was field classified. These wells are sampled by PBA and assayed regularly by the Army Environmental Hygiene Agency (AEHA) for selected contaminants. The downgradient wells are located as shown on plate X-17.

D. Auger sampling

(1) Twenty-three auger holes, mostly 40 feet deep, were drilled in the Arkansas River flood plain at the site in the fall of 1983. Locations of these borings are shown on plate X-17. Three hand auger holes were drilled on the northeast side of the lagoon. Two holes (holes 15 and 16) were drilled northwest of the site within the floodplain to establish background heavy metal concentrations. Soil from the auger holes was described in the field, classified in the laboratory, and tested for the toxic heavy metal contaminants as defined by RCRA, these being arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver. In addition, total phosphorus and zinc were determined because of their suspected presence at the site, although neither are RCRA toxic contaminants. Zinc was found in high concentrations during the 1973-75 Contaminated Area Survey Project. Zinc, in the form of zinc oxide, is a major constituent of smoke mixes disposed of at the site. Because some white phosphorous contaminated materials were stored at the site, total phosphorus was determined in some of the borings as well.

(2) Each run with the auger was limited to 3 feet. To prevent mixing of materials or sampling material that had pulled off from the wall of the hole, only the interior portion of each sample was used. Material was taken from the entire 3-foot sample and put into a glass jar and shipped daily by bus to the Corps of Engineers, Southwestern Division Laboratory in Dallas. Groundwater was sampled in some of the holes and analyzed for heavy metals. If the hole penetrated a clay layer, it was backfilled with grout.

c. Undisturbed sampling. One denison sample of clay was obtained from a boring offset slightly from hole 4 from a depth of 15.5 to 17 feet. The sample was obtained for a laboratory premeability test and is representative of the natural clay stratum beneath the site.

d. Lagoon traverses. Three traverses were made across the lagoon by boat from the southwest shore to the tree line located in the middle of the lagoon. Sediment samples were taken at 10-foot intervals by a Ponar dredge along the first and third traverses, and by a ball check core sampler on 5-foot intervals along the second traverse. The sampler took an 18-inch core from which an upper sample was taken at the water/sediment interface and a lower sample was taken from the deepest material ratained in the sampler. A total of 41 upper and 24 lower samples were taken. The lagoon traverses are shown on plate X-18.

e. Grab sampling. To supplement the auger and lagoon sampling, water, soil, and sediment samples were taken along both sides of the lagoon. Three water samples were taken from the lagoon, eleven sediment samples were taken from both sides of the lagoon near the shore, and 2 soil samples were taken from the back side of the lagoon. These sampling locations are also shown on plate X-17.

f. Burned fill study. In order to determine the thickness and extent of the burned fill, 135 shallow holes were made with a drilling hand auger, posthole digger, or shovel.

Analysis.

a. Background levels of contaminants. In order to define contamination, determination of the background concentration of contaminants was made. Concentrations of contaminants in samples from borings in the contaminated area were compared with the background concentrations, and the limits of contamination were established. A determination of the natural (background) concentrations of the chemicals in the soil at Site 20A was made by drilling two background holes in a geologically similar area that was as close as possible to the site but free of the effects of contamination from the site. Two different material types were encountered, clay and silt, and each type was found to have different background chemistry. Eight of the soil samples tested were clay and two were silt. Mean concentrations for each chamical in clay and mean concentrations for each chemical in silt were calculated. A sample standard deviation was calculated for each chemical in clay. If data are normally distributed, and a value is chose two standard deviations around the mean, then approximately 95 percent of the data will be within these values. If a measured value exceeds these 95 percent confidence intervals, if is probable that the measured value is not within the normal range of background values for that chemical. In the silt, a standard deviation was not calculated because there were only two values for each chemical. In the clay, two standard deviations averaged to be 86 percent of the mean value, so the upper limit of the 95 percent confidence interval in the silt was also taken to be the mean plus 86 percent of the mean. These 95 percent confidence intervals for clay and silt are tabulated in table 6.

TABLE 6

BACKGROUND SOIL CHEMISTRY
(All values in mg/kg)

Contaminant	CLAY Background Mean	CLAY Upper Limit of 95% Confidence Interval (1)	SILT Background Mean	SILT Upper Limit of 95% Confidence Interval (1)
Arsenic (As)	7.1	13.9	1.9	3.6
Barium (Ba)	78.6	150.4	41.6	77.4
Cadmium (Cd)	0.5	-	0.5	-
Chromium (Cr)	5.0	-	5.0	-
Lead (Pb)	13.5	21.1	5.2	9.6
Mercury (Hg)	0.1	-	0.1	-
Selenium (Se)	0.1	-	0.1	-
Silver (Ag)	0.5	-	0.5	-
Zinc (Zn)	44.5	80.3	21.7	40.4
Total Phosphate (TPO_4)	368.1	771.3	249.5	464.1

(1) An upper limit of the 95% confidence interval was not calculated for the chemicals which were below minimum reported values in the background holes.

b. Depth of contamination determination.

(1) Method. The depth of contamination at Site 20A was determined by comparing measured concentrations of contaminants with background levels (as discussed above). Sample test results are plotted with depth on the same figure as the background levels so a comparison could readily be made. Once the results are plotted in this manner the depth of contamination is readily determined.

(2) Procedures for determining laboratory tests. Samples from hole 3 and 4, both located in the burned fill area, were tested for lead, zinc, barium, arsenic, chromium, cadmium, selenium, silver, mercury, and total

phosphate. The background holes (15 and 16) were also tested for these chemicals. Based on the results, lead was found to be the contaminant which best indicated the limits and degree of contamination at the site and was selected for testing in future borings. Zinc was found to be present in concentrations above background levels and was found to be more mobile than the eight RCRA toxic heavy metal contaminants. Although the limits of significant zinc were established they are not indictive of the limits of any of the toxic contaminants. Holes 1 through 5 were tested total depth for lead, but in most of the holes only the upper portion (about 10 to 20 feet) was tested. Once it was determined that the burned fill was heavily contaminated with lead, after consistent results from about half a dozen selected holes, the fill was not tested further. Barium, which was found in low concentrations in the groundwater monitoring wells, was determined in samples from several holes. Total phosphorus was tested in holes 4 and 5 which were located near a storage area for white phosphorus contaminated materials. Lagoon and soil grab samples were also selectively tested to determine the depth and extent of contamination. Jar samples not tested, as well as the remainder of samples which were tested, and the leftover acid digests, are being retained by the laboratory. EP toxicity tests were performed on four of the most highly contaminated samples from Site 20A. Two samples of burned fill material. one sample of clay beneath the burned fill, and one lagoon sediment sample were tested. Test results are presented in table 7. None of the test results exceeded the limits for EP toxicity set forth in RCRA.

TABLE 7

EP TOXICITY RESULTS
(Values in mg/l)

Sample #	Depth (ft)	As	Ba	Cd	Cr	Pb	Hg	Se	Ag
(RCRA limit)	-	5.0	100.0	1.0	5.0	5.0	0.2	1.0	5.0
20A-3 Jar 3	3.0-6.0	0.00075	3.2	0.01	0.01	0.045	0.0002	0.0018	0.01
20A-4 Jar 3	6.5-9.5	0.00075	3.55	0.11	0.01	0.170	0.0001	0.020	0.01
20A-4 Jar 4	9.5-12.5		0.2			0.04			
SD-2 (lagoon sediment)	surface	0.00175	3.55	0.015	0.01	0.01	0.0002	0.019	0.01

c. Contamination results.

(1) Burned fill contamination. The burned fill is highly contaminated with lead in every sample tested, both on the ground surface and beneath the lagoon, with lead concentrations as high at 2700 mg/kg. High concentrations of zinc are also present in the burned fill. Lesser amounts of barium. arsenic, chronmium, and total phosphorus also occur in the fill. Plate X-19 shows the limits and thickness of the burned fill material.

(2) Soil contamination. Sections A-A through D-D. on plates X-20 through X-22, show maximum depth of significant lead and zinc. The overwhelming majority of the contamination is confined to the burned fill material. Lead occurs is significant quantities in the soil in hole 25. This soil, which is described as a gray, organic-appearing sandy clay, has a lead concentration of 380 mg/kg lead and is contaminated for a depth of 3

feet below the fill. Hole 20 has some lead in the upper 3 feet below the fill at a concentration of about 16 mg/kg. Lead does not occur in significant quantities in any holes drilled outside the burned fill area.

(3) Lagoon sediment contamination. Contamination of the lagoon sediment is shown on plate X-18, which consists of a location map and a tabulation of results. Traverse 2 across the lagoon is shown on section C-C, plate X-22. Lead contamination is most severe near the southwest shore, in association with the burned fill, and drops off rapidly away from the burn area. Lead concentrations are greater than 21.1 mg/kg (background level in clay soil) in samples taken at the sediment/water interface. These concentrations are confined to the upper 1-foot of the sediment over approximately 75 percent of the lagoon; and are less than 200 mg/kg, except for the portion where burned fill exists, about 20 feet into the lagoon from shore. In this portion of the lagoon, where burned fill exists, lead concentrations are greater than 200 mg/kg and extend approximately three feet below the burned fill.

(4) Lagoon water contamination. All RCRA-listed toxic metal concentrations from the three lagoon water samples were below drinking water standards. Most were below minimum reported values.

(5) Groundwater contamination. Groundwater encountered at Site 20A belongs to the Jackson/Quaternary aquifer. The gradient is very steep on the western half of the arsenal where the predominantly fine-grained materials on the Jackson Group are close to the surface; and nearly flat on the eastern half, sloping gently toward the Arkansas River through the terrace and flood

plain deposits. This aquifer generally yields only very small amounts of poor quality water. The water is not drinking water quality and is not used for any purpose in the vicinity of the arsenal. The aquifer that supplies the drinking water to the area is the Sparta Sand, which is about 600 feet deep beneath the site. The Sparta is protected by the Jackson and upper Claiborne groups which have a low vertical permeability. Groundwater data are available from groundwater monitoring wells and from samples taken from several of the auger holes. A summary of these data is given in table 8. Groundwater analyses confirm the fact that the contamination is primarily confined to the burned fill.

TABLE 8

GROUNDWATER CHEMISTRY AT SITE 20A
(Values in mg/l)

	Barium		Lead		Zinc
	C of E	AEHA	C of E	AEHA	C of E
Downgradient wells	.13-1.79	0-1.9	.02-.13	0-.01	.02-.08
Upgradient wells	.11-.23	0-.59	.03-.04	0	.04-.09
Auger Holes 19 to 25	.11-2.63		.01-.05		.02-.70
Drinking water standards	1.0(1)		.05(1)		5.0(2)

(1) National Interim Primary Drinking Water Regulation
(2) Secondary Drinking Water Standard

4. Stratigraphic results.

As shown by the topography and monitoring well borings, Site 20A is located within the present flood plain of the Arkansas River. Geology from the drill holes is shown on geologic sections A-A through D-D, plates X-20 through X-22. Locations of these sections are shown on plates X-17. The deposits are all unconsolidated materials and consist of clay, silt, and sand. The clay is generally low plasticity with a liquid limit of 35 to 40 percent and a moisture content of 30 to 40 percent. A field permeability test conducted in hole 4 gave a value of 10^{-6} cm/sec for the clay. A laboratory permeability test on an undisturbed sample of this clay resulted in a value of 10^{-8} cm/sec. Section A-A, plate X-20, shows thicknesses of up to 25 feet of clay. The lateral extent of the clay strata thicker than 5 feet is shown on plate X-23. Several pockets of high plasticity clay with liquid limits above 60 also occur. Sand and silt predominate as shown on section B-B, plate X-21. The sand is generally silty and clayey with a permeability of about 10^{-5} cm/sec. This figure was calculated from recharge tests performed on the downgradient monitoring wells. The burned fill consists of incinerated debris and scrap metal. This material covers about 5 acres of the site and comprises about 53,000 cubic yards. As shown on sections C-C and D-D, plate X-22, this material is present as a thin veneer and thickens rapidly toward the lagoon. This material appears to have been pushed into the lagoon after burning operations and has a maximum thickness of 12 feet. The burned fill is several feet thick at the southwest shore of the lagoon and extends about 20 feet into the lagoon. The water table elevation equals the lagoon water surface at elevation 201.8, and is nearly flat across the site with an eastward gradient of less than 1 foot per mile toward the Arkansas River. The lagoon is fed by groundwater. As shown on the geologic sections, the water table occurs in the thicker portions of the burned fill as well as in both sand and clay.

SITE 20B - WHITE PHOSPHORUS SLAG BURNING AND DISPOSAL AREA

1. Site Description. The White Phosphorus Slag Disposl Area is an abandoned white phosphorus (WP) burning and disposal area located just south of site 20A. The southern portion is relatively flat and grass-covered at about elevation 230. The elevation drops to 210 north of an escarpment which divides terrace and floodplain deposits. The floodplain portion of the site is very heavily wooded and is littered with dozens of rusted 55-gallon drums, wood pallets, WP grenades and other small WP munitions. There is a lagoon several hundred feet from the slope. Tests on randomly selected munitions did not indicate that there was any WP left in them. Remains of a 4-inch pipe, which apparently took liquid waste materials from a hopper to the bottom of the hill, still exist. Burned material exists beneath dense vegetation in the floodplain area at the toe of the escarpment. Boring locations are shown on plate X-24.

2. Investigations. Fifteen auger holes, 5 to 40 feet deep were drilled at Site 20B on the top of the slope and at the base near the lagoon. Two lagoon sediment samples and one lagoon water sample were also taken.

3. Results.

a. Contamination. Bulldozer operations in the floodplain revealed a distinct blackish color to the soil at the site. This is shown as fill on geologic sections A-A and B-B, plate X-24. Laboratory results showed elevated lead, barium, zinc and total phosphorus. Zinc is not a RCRA listed toxic contaminant, however it is a major constituent of smoke mixes. Total phosphorus, which was as high as 13,000 mg/kg. is not a toxic contaminant but is an indicator that white phosphorus was present at one time. The cleaup proposed is based on the presence of lead, which is a toxic contaminant and is high in the holes which have elevated levels of total phosphate. Lead concentrations are as high as 450 mg/kg and extend deeper than the depth of testing, which was 3 feet. An estimated volume of 15,000 cubic yards of contaminated soil and fill is present at the site. The lagoon has 60 to 80 mg/kg lead on the side nearest the disposal area. These levels are similar to the levels in the lagoon at site 20A.

b. Stratigraphy. This site is located in both terrace and floodplain deposits. The holes drilled in the floodplain show highly variable amounts of clay and silt. Geologic sections A-A and B-B, plate X-24, show that the thickest clay is located both north and south of the fill area in the floodplain. There is no suitable clay in the area where contamination exists.

c. Groundwater. The permanent water table is near the ground surface in borings 3, 4, and 5 and is at the same level as the water in the lagoon. The water table is nearly flat and slopes very gently to the east.

SITE 23A - HC TEST POND

1. Site Description. Site 23A, the HC Test Pond, is a 1½-acre pond formerly used for testing smoke pots and smoke grenades. The site was also used as a dump area for production-related materials. HC is a screening smoke composed of 47% zinc oxide, 47% hexachloroethane (a RCRA-listed toxic organic

compound), and 6% aluminum. The site consists of a pond and a wooded area. ...ing in elevation from 232 to 238.

... Investigations. Seven monitoring wells and 27 auger holes varying in depth from 3 to 40 feet have been drilled at the site. One hole was augered to 17 feet and sampled an additional 9 feet with Denison sampler. Half of the holes (as shown on plate X-25) were drilled near the eastern edge of the pond. The others were scattered about the site in drainages, low areas, and other areas of suspected contamination. The undisturbed samples will be tested for permeability. The pond sediment has not been investigated.

3. Results.

a. Contamination. The major RCRA-listed metal contaminants at Site 23A are lead and zinc, with lesser amounts of mercury, cadmium, chromium, and barium. Hexachloroethane, a listed RCRA waste, is present as well. These contaminants are found both in the fill material which appears to be HC residue, and the soil beneath the fill. EP toxicity tests show the fill and the soil do not exceed RCRA limits. The eastern edge of the pond was apparently used as a dump area and contains a whitish material with 300,000 to 500,000 mg/kg zinc, 240,000 mg/kg hexachloroethane, and 500 mg/kg lead. This fill material is 11 feet thick and thins rapidly away from the pond. Approximately 1 foot of soil is contaminated beneath the fill. Other areas of contamination include a small area in the northeast corner of the site (holes 9 and 10) and a dump/burn area on the southwest shore of the pond (hole 20). None of the depressions, ditches, or streams investigated show any contamination. Contamination extends into the pond sediment but the extent and depth are unknown. An estimated 25,000 cubic yards of contaminated materials (not including the pond water or the unknown quantity of smoke pots, contaminated sediment and soil beneath the pond) exist at the site. Very little groundwater contamination data is available at this site. Only one monitoring well (146) at the site is screened in the permanent water table. Wells 147 and 149 penetrate the perched water table only. Well 148 was screened through both systems, but has been plugged to prevent flow from the perched to the permanent water table. Limited available data indicate significant groundwater contamination at the site in the perched water table and much lesser contamination in the permanent water table. Three new wells have been installed, one in the perched water and two in the permanent water table. One water sample from the pond was tested and not found to contain any of the RCRA listed metal contaminants above drinking water standards.

b. Stratigraphy. Approximately 20 to 23 feet of terrace silt, sand, and silty clay overly the Jackson Group. The Jackson at Site 23A has about 20 feet of clay-shale which overlies a silty sand at about 42 feet. A geologic section is presented on plate X-25. The clay-shale appears to be similar to the clay-shale at the FY83 landfill site and should be suitable for use in an encapsulation scheme.

c. Water Table. Perched water occurs above the clay-shale at about elevation 225. The permanent water table occurs at about elevation 200 and slopes gently to the northeast.

SITE 24 - OLD THERMITE DISPOSAL AREA

1. Site Description. Site 24 is a 4 acre area which was formerly used for disposal of thermite waste from the Quality Assurance Drop Tower. Lead oxide wastes from the Bomb Washout Facility were also disposed of here. Much of the site is contaminated with heavy metals, including barium, lead, and zinc. The site is located in the southern portion of the arsenal, inside the production area.

2. Investigations. A total of 12 auger borings from 5 to 40 feet deep and 4 groundwater monitoring wells have been completed at the site. Nine of those borings are in the disposal area and 3 are in the drainages north and south of the site. Boring locations are shown on the site plan, plate X-26.

3. Results.

a. Contamination.

(1) Disposal Area. The fill material varies in thickness from 1 to 5 feet as shown on the geologic sections, plates X-26 and X-27. It is contaminated with lead, zinc, barium, cadmium, and chromium. Lead contamination is the greatest, with concentrations as high as 18,000 mg/kg. The soil is generally contaminated in the upper foot with slightly elevated levels of lead, cadmium and chromium. All three of the drainage sediment samples showed 1 to 2 feet of lead contamination. EP toxicity tests show the fill to be above RCRA limits for lead.

(2) Drainages. Boring 8 was drilled upgradient of Site 24 in the stream that drains Site 27. This boring had high levels of the Site 27 contaminants, lead and barium, to a depth of 2 feet. Boring 7 was drilled in the same drainage downgradient of the site and was not significantly higher in lead and barium than boring 8. Although some of the fill from Site 24 appears to have washed into this stream, the contamination is apparently coming from off-site. The same condition is probably true for the north drainage as well.

(3) Groundwater. Groundwater monitoring wells do not indicate contamination in the permanent groundwater system from Site 24. A sample of perched water showed levels above drinking water standards for only barium. These data indicate that the existing clay materials are effectively preventing groundwater contamination at the site.

(4) Quantities. There is an estimated 10,200 cubic yards of contaminated fill, and 4,800 yards of contaminated soil, for a total of 15,000 yards at the site.

b. Stratigraphy. All 4 of the monitoring wells and boring 1 penetrated the Jackson Group, which is about 15 feet deep. The upper 5 to 8 feet of the Jackson Group in the monitoring wells is clay-shale and is underlain by sand. This clay-shale thins to about 1 foot underneath the site. The Jackson Group is overlain by terrace deposits of sand, silt, and clay. The clay, although greater than 5 feet thick over the northern 2/3 of the site, has liquid limits of only 21-29. The location of geologic sections A-A and B-B (plates X-26 and X-27) are shown on the site plan, plate X-26.

c. Water Table. The permanent water table at Site 24 is about elevation 201, 30 feet below the ground surface, and slopes gently to the southeast. Perched water generally occurs above the terrace clay where it is thickest, about 1.5 to 7 feet below ground surface. It also occurs above the clay-shale about 12 to 13 feet deep.

SITE 26 - PRODUCT ASSURANCE DROP TOWER

1. Site Description. Site 26 is the Product Assurance Drop Tower and Test Basin. The drop tower and test basin have been in existence since the Arsenal's construction in the 1940's and has been used for testing grenades and various pyrotechnic devices. The drop tower and test basin is an active facility. This project consists of cleanup of contaminated soil and debris outside the test basin and providing runon/runoff control for the basin adequate for a 25 year, 24 hour storm. Site 26 is flat at approximate elevation 238 and covers approximately 2 acres. The area has been cleared of trees, but grass grows with no apparent distress outside paved areas and those with a heavy accumulation of burned debris. The test basin is a 30 foot square concrete-lined test basin bordered by a concrete curb. Precipitation falling on the test basin drains into an industrial sewer line that was installed in 1973. The test basin is within a 60 foot by 40 foot area bounded by a 1 to 2 foot high concrete wall. There is burned residue within the entire 60 foot by 40 foot area and approximately 20 feet outside the wall on the north and east. Scattered debris and burned residue are present over the entire 2 acre site. A 30 foot square reinforced concrete pad heaped with burned debris is located southeast of the drop tower. Some debris is present outside the pad. Another small area (50 foot square)

...tween the drop tower and concrete pad is covered with a pavement like ...ue. Both areas outside the drop tower are to be cleaned up as part of ...s site.

... Investigations. Eight preliminary borings were recently performed at the site of which one was 40 feet deep and the others were 10 feet deep. Both the area outside the test basin and the area around the concrete pad were investigated. The 40 foot hole encountered the water table and a water sample was taken. No perched water was encountered at the site. The eight preliminary borings are located on plate X-28.

3. Results.

a. Contamination. The burned debris present at the site has high concentrations of barium (11,000 mg/kg), chromium (670 mg/kg), and lead (1100 mg/kg). The soil is contaminated to a maximum of about half those levels to a maximum depth of 6.5 feet. Approximately 3000 cubic yards of contaminated material exist at the site. Results of EP toxicity tests show the material to be a non-RCRA waste.

b. Stratigraphy and Water Table. Site 26 rests on terrace deposits approximately 20 feet thick. The terrace deposits at this site consist of silt with occasional silty clay lenses. Beneath the terrrace deposits is the clay shale of the Jackson formation. The clay shale is about 8 feet thick and is underlain by silty sands. The water table is in these silty sands at a depth of 38 feet below ground surface, approximate elevation 200. A geologic section on plate X-28 shows subsurface conditions at the site.

SITE 27 - AGENT BZ POND

1. Site Description. Site 27 is an unlined ¼-acre lagoon which received heat-treated agent BZ, impregnite, thermite, and lead oxide waste until 1972. The area around the BZ pond is relatively flat at elevation 236. A sandy fill is present on the banks of the pond. The pond is approximately 10 feet deep and has near vertical sides shored with concrete. The elevation of the water surface in the pond is 232. There is a concrete tank north of the pond which held a sand filter bed and several pipes entering the pond.

2. Investigations. Twenty-four borings were performed around the pond and in a natural drainage north of the pond. Sediment and water samples were taken from the pond. Four groundwater monitoring wells were installed at the site in 1981. Two more were added in 1984. Locations of wells and borings are shown on the plan of explorations, plate X-29.

3. Results.

a. Contamination. The primary contaminants at site 27 are lead with concentrations as high as 10,000 mg/kg and barium with concentrations as high as 6500 mg/kg, which are present in the sandy fill around the pond. EP toxicity tests show the fill to be below RCRA limits. The sandy fill in as deep as 6 feet near hole 5. Soil is contaminated 2 to 3 feet below the base of the fill. An estimated volume of 9000 cubic yards of contaminated fill and soil exist at the site. This assumes an average 5 foot depth of contaminated material in the area explored, including the area beneath the pond. The water in the pond has concentrations of 9.6 mg/l barium and

.. mg/l lead which are above the respective drinking water standards of .. mg/l and .05 mg/l respectively. The perched water sample from hole 5 has concentrations of 7.1 mg/l of barium and .04 mg/l lead. The permanent water table sample from hole 5 had 0.2 mg/l barium and.1 mg/l lead. The soil sample from the zone where the permanent water table is present had high concentrations of barium and lead. Three of the four monitoring wells at the site, wells 154, 155, and 157, are set in the permanent water table and the fourth, well 156, is set in the perched water table. Two of the wells in permanent water table. wells 155 and 157, were reading perched water elevations, indicating a nonfunctioning seal in those wells. Those wells were plugged in 1984. Minor amounts of lead and barium have been detected in levels below drinking water standards in three of the wells. Two sets of monitoring wells were installed in 1984 to replace wells 155 and 157. Each set consisted of a well in the perched water and a well in the permanent water table.

b. Stratigraphy and Water Tables(s). The BZ pond is located on terrace deposits 15 to 20 feet thick. The terrace deposits consist of interbedded sands, silts, and clays. The clays have low plasticity and are not continuous. These terrace deposits are underlain by 8 to 9 feet of low to high plasticity clay-shale. This clay-shale supports perched water in the terrace deposits above. Below this clay-shale is at least 30 feet of silty sand. The permanent water table is in this material at approximate elevation 202. A geologic section is presented on plate X-29.

SITE 29 AND 29A

SOLID WASTE ARK-LA SITE

SALT PILE

1. Site Description. Site 29 is a 40 acre site which was used in the 1940's for the manufacture of chlorine for both the mustard and lewisite operations. Chlorine production was the only portion of the mustard and lewisite processes which took place on the site. From 1950 to 1969, the site was leased to the Ark-La Chemical Corporation which also produced chlorine. All of the buildings from this site have been removed as well as most of the foundations. Drawing X-30 shows the former location of these buildings, loading docks, and other structures. Building 52330 was the main electrolysis building which contained 200 cells (all containing lead) with which chlorine gas was separated. Site 29A, located in the eastern portion of Site 29 as shown on the site plan, is an asphalt-covered pile of salt containing about 100 cubic yards. The material is non-toxic insoluable residue (salt) used in the chlorine production.

2. Investigations. Two 40-foot auger holes and 25 5-foot auger holes were drilled at Site 29. These borings were located in the vicinity of the buildings and structures and are shown on the plate X-30. A sample of material beneath the asphalt in the salt pile was taken. This site has no ground water monitoring wells.

Results.

a. Contamination. Before soil tests were assigned, material in the salt pile was analyzed. Accordingly, the 8 RCRA-listed toxic metals, sodium, and chloride were tested. These total about .01% of the total. Calcium accounted for 2.5% of the material and silica another 20%. The only contaminant in the salt was lead at a concentration of 51 mg/kg. The salt could not be digested in the strong acid used by the laboratory. The same salt, which is granular in nature, is present on the ground surface at the site. Because it yielded minor contamination under these harsh conditions, the scattered areas where the salt is present will not be encapsulated or removed in the closure plan. The only contaminant found in the soil from recent borings above established background levels was lead. Two areas had high lead, those borings near building 52330, with values as high as 7300 mg/kg, and those borings near buildings 52410 with values as high as 200 mg/kg. The sample with lead at 7300 mg/kg was subjected to EP toxicity tests and was above RCRA limits. An estimated volume of 18,300 cubic yards of contaminated material is present at the site. The salt pile consists of approximately 100 cubic yards. No data are available on groundwater quality.

b. Stratigraphy. Site 29 rests on a residual clay overburden about 4 to 5 feet thick which rests on Jackson clay-shale in excess of 35 feet thick. Some silt and sand are present in the overburden. Laboratory classifications are not yet available. A geologic section through the site is shown on plate X-30.

c. Water Table. The permanent water table is at approximate elevation [illegible]0, about 10 feet below ground surface. The water table slopes both to the northeast and southwest from a high area in the middle of the site. Perched water is found in some of the sand beds above the clay shale.

SITE 31A

1. Site Description. Site 31A is an abandoned ½ acre product assurance test range located north of bunker 33-740 in the south production area. The site was previously used for testing smoke grenades and some riot control agents before its use was discontinued in 1973. The site is flat at approximate elevation 237 with surface drainage toward the southwest. A discolored (gray) plume of soil is present at the site on which vegetation does not grow. A sewer runs under the site and a manhole for this sewer is located in the middle of the discolored area. The remnants of some type of structure are present at the site as shown on the plan of explorations, plate X-31.

2. Investigations. Five auger holes were drilled at Site 31A. One 40 foot auger hole was drilled and the rest were 5 or 10 feet deep. A water sample was taken from the perched water table in the deep hole. Boring locations are shown on the plan of explorations, plate X-31. Thirty-six shallow auger holes were drilled at site 31A in the Contaminated Area Survey Project.

3. Results.

a. Contamination. A plume of soil with gray discoloration is present at Site 31A. The soil contains lead with concentrations as high as 10,000 mg/kg. The depth of contamination is a maximum of 2 feet. The estimated quantity of contaminated material present at the site is 1,500 cubic yards. Results of EP toxicity tests show the material to be non-RCRA wastes.

b. Stratigraphy. Site 31A lies on terrace deposits approximately 20 feet thick. The terrace deposits consist of sands and silts interbedded with beds of silty clay. A silty clay stratum varying from 3 to 6 feet thick is present within 3 feet of the surface. See Geologic Section plate X-31. The terrace deposits rest on the clay-shale of the Jackson Group which is approximately 10 feet thick. Silts and sands underlie the clay-shale. The permanent water table is 35 to 40 feet below the ground surface with a very slight gradient to the northeast. There is a shallower perched water table at 8 feet that is supported by the clay-shale of the Jackson Group.

SITE 31B - STANDBY GRENADE TEST BASIN

1. Site Description. Site 31B is a 30-foot by 30-foot active test grenade basin. It is a shallow, concrete-lined structure located on the western edge of a pond. A concrete curb borders the test basin and a shed is located south of the test basin. Precipitation falling onto the basin drains into an industrial sewer line and is transported to the pollution abatement facility. Smoke grenade and pyrotechnic production items have been tested at the facility since its construction in 1973. The entire site lies in an area approximately 1/10 of an acre in size. The site is flat at approximate elevation 237 and surface drainage outside the basin is to the east toward the pond. Adequacy of the runon/runoff control for a 25 year 24 hour storm

will be evaluated and any contaminated soil or debris outside the basin will be cleaned up.

2. Investigations. Five auger holes were drilled at Site 31B. The holes ranged in depth from 5 to 10 feet. One hole was drilled in the pond near the shore. Boring locations are shown on the plan of explorations. plate X-31.

3. Results.

a. Contamination. No contaminated soil exists at site 31B.

b. Stratigraphy. Site 31B lies on terrace deposits approximately 20 feet thick. The terrace deposits consist of sands and silts interbedded with beds of silty clay. See Geologic Sections, plate X-31. The terrace deposits rest on the clay-shale of the Jackson Group which is approximately 10 feet thick. Silts and sands underlie the clay-shale. The permanent water table is 35 to 40 feet below the ground surface with a very slight gradient to the northeast. There is a shallower perched water table at 8 feet that is supported by the clay-shale of the Jackson Group.

SITE 34, NCTR EQUALIZATION POND

1. SITE DESCRIPTION. The NCTR Equalization Pond is a 1.5 acre site with a ¼ acre lagoon that was used for two purposes. The first, during the 1969 closedown of the Directorate for Biological Operations (DBO), was as a flow equalizing and neutralizing area for a caustic sludge resulting from the destruction of the stock of biological agents. The sludge was neutralized in

pond and the effluent then went to the North Oxidation Pond. When the National Center for Toxicogical Research took over the facilities that formerly housed the DBO, the Equalization Pond was used as a flow equalization chamber and settling pond for the domestic sewage going to the North Oxidation Pond. Its use was terminated in 1980 and the lagoon is no longer connected to either facility. No known toxic contaminants were introduced into the pond at any time during its use. A pumphouse is still present at the site, and the piping entering and leaving the pond is still present. The site is flat at approximate elevation 268 with the top of the lagoon levees approximately 5 feet above natural ground. The water elevation in the pond is approximately 270. Grass grows with no apparent distress on and around the lagoon levees. Vegetation also exists in the pond and is thick enough to make its removal necessary to obtain sediment samples.

c. Investigations. Four auger holes were drilled at the site. One auger hole was 40 feet deep and the other three were 10 feet deep. Boring locations are shown on the plan of explorations, plate X-32. Water and sediment samples were taken from the north and south sides of the pond.

3. Results.

a. Contamination. No toxic contaminants have been detected at site 34 in either the water in the pond or soil around the site. The sediment however, contains concentrations of lead (65 mg/kg) and chromium (74 mg/kg) as well as barium, zinc, and some silver. Tests for solvents and other organics which may be present will be conducted during final investigations. No EP toxicity tests will be performed. Since only sediment grab samples have been taken to date, a 5 foot depth of contamination is assumed until additional sampling and testing can be completed. A possible 4000 yards of contaminated materials may exist at the site.

b. Stratigraphy. The NCTR equalization pond rests on terrace deposits approximately 22 feet thick. The terrace deposits consist of interbedded silt and sand with several thin beds of silty clay. The Jackson clay-shale underlies the terrace deposits and is approximately 14 feet thick. A clayey sand underlies the clay-shale.

c. Water Table. The permanent water table is approximately 23 feet below natural ground at elevation 245. The gradient is to the east at approximately 25 feet per mile. A perched water table was present near the surface during drilling operations.

SITE 38, IMPREGNITE SLUDGE LAGOON

1. Site Description. The impregnite sludge lagoon is a 50-foot by 50-foot pond located just south of the water laboratory in the production area. It contains about 5 feet of impregnite sludge and solvents. During periods of rain, water stands in the pond to a depth of several feet. Runoff control is provided since the site is tied into Central Waste Treatment. Impregnite is a chloroamide compound which is fixed in clothing by a chlorinated paraffin binder.

2. Investigations. Four 10-foot auger holes were drilled outside of the pond at each corner. The pond was dewatered by pumping into the adjacent runoff-control sewer and a 10-foot hand auger hole was drilled in the center

of the pond. Groundwater monitoring wells were installed in 1983. Laboratory classifications of materials from the wells and three-quarters of chemical data are available. The auger holes and downgradient monitoring wells are shown on the plan of explorations, plate X-33.

3. Results.

a. Contamination. Test results from the boring in the center of the pond indicate that the sludge does not contain any detectable silver, arsenic, barium, chromium, mercury. lead, or selenium. The sludge does contain 1.8 to 3.2 mg/kg cadmium and 25,000 mg/kg zinc, however zinc is not a RCRA-listed toxic metal. Solvents been identified in the sludge. The 4 holes outside the pond contained no detectable cadmium, background levels of lead, and 10 to 200 mg/kg zinc. The soil beneath the sludge also had no detectable cadmium, background levels of lead, and 60 to 520 mg/kg zinc to a depth of 5 feet below the fill. The sludge plus 1 foot of soil beneath the sludge totals about 900 cubic yards of contaminated material. Since only high levels of zinc are found at the site, and zinc is not a toxic contaminant, no EP toxicity tests are proposed. The standing water in the pond contained 0.11 mg/l lead (higher than the primary drinking water standard of 0.05 mg/l) and 80 mg/l zinc (higher than the secondary drinking water standard of 5.0 mg/l). The monitoring wells, set in both the perched and permanent water tables show no contamination from the site.

b. Stratigraphy. Site 38 is situated on terrace deposits of silt, sand, and some clay, about 20 feet thick. The Jackson Group is situated below these terrace deposits and consists of high plasticity clay-shale, in excess of 30 feet thick. A geologic section is presented in plate X-33.

c. Groundwater. Perched water occurs at elevation 223 (16 feet below ground surface) in the sand which overlies the Jackson. The permanent water table occurs about elevation 200 (40 feet deep) and slopes very gently to the east.

HAZARDOUS LANDFILL

1. Site Description. The hazardous landfill will be located about one mile south of the FY 83 landfill and between the North Exclusion Area and the west boundary patrol road. The site is very heavily wooded and is located on a rise just south of Eastwood Bayou at about elevation 320. Two trenches for production wastes (43,750 cy each) and one for wastes from the closure sites (55,000 cy) are proposed. The tentative location of these cells is shown on plate X-34.

2. Investigations. Three 40-foot auger holes and one 10-foot backhoe test pit have been conducted. Two 40-foot auger and splitspoon borings were drilled on the patrol road west of the site by Forth Worth District. One of these holes was deepened to 200 feet with a rockbit for the purpose of geophysical logging. One boring was drilled by Waterways Experiment Station on the patrol road. Each of these holes has been made into a monitoring well screened into the permanent water table. Each of the 3 borings in the

Proposed landfill area has two piezometers: one screened in the permanent water table and one in the perched water table.

c. Geology. The geology is very similar to that at the FY 83 landfill. About 5 feet of residual or terrace silt and clay overburden rest on the Jackson Group. The Jackson consists of about 15 feet of clay-shale which is underlain by a more permeable zone of silty sand and clayey silt from 20 to 30 feet. Below 30 feet is clay-shale. Overburden clay is low plasticity and sandy and may be gravelly at the Jackson contact. The Jackson clay-shale has liquid limits ranging from 50 to over 100 and is classified as either CL or CH. Laboratory tests from WES well 88 give the permeability of the in-situ clay-shale as $1x10^{-6}$ cm/sec and of the more permeable silty zone as $3x10^{-5}$ cm/sec. Two geologic sections have been drawn through the landfill and are presented on plate X-35. Compaction tests were performed on samples of overburden material and the Jackson clay-shale. Permeability tests were performed on specimens of each material remolded to 95% of standard Proctor density at optimum water content. Results are summarized in Table 9.

TABLE 9

PERMEABILITY TESTS ON REQUIRED EXCAVATION FROM LANDFILL

Type of Material	Depth	L.L.	P.L.	Moisture Content	Permeability (cm/sec)
Overburden (bags)	2.0-4.0	26	14	13.2*	$6.8x10^{-8}$
Overburden (jar)	2.0-2.5	26	16	22.5**	--
Jackson (bags)	6.0-8.0	83	24	32.9*	$2.0x10^{-8}$
Jackson (jar)	6.0-6.5	113	30	31.4**	--

* Optimum water content as determined from the standard proctor compaction test.

** Natural water content of material in field.

Groundwater. The permanent water table occurs about elevation 295. Although the regional flow direction is easterly, the water table is much more reflective of the topography where the finegrained Jackson sediments are near surface and appears to be flowing in a northesterly direction at this site. The rainy winter and spring of 1984 has caused a 2 to 5 foot rise in the water table. Perched water was encountered in hole 331 in all readings and in both 329 and 330 in all but December 1983 and January 1984 readings. The perched water table was at the ground surface from February to May 1984. Both the permanent and perched water tables are shown on the geologic sections on plate X-35.

5. Design Considerations. Subsurface conditions are very similar to the FY 83 landfill site and the same basic design can be incorporated into the FY 86 landfill. Possible design improvements and critical subsurface conditions are discussed below:

a. Groundwater. Guidelines for design of hazardous waste landfills from the Arkansas Department of Pollution Control and Ecology (ADPCE) indicate that the base of the closure cells shall be a minimum of 10 feet above the water table. Groundwater conditions at this site will require that the cells be sited with the base of the cells at required elevations such that this ADPCE guideline is met. A groundwater control system, similar to the one designed for the FY 83 landfill, to control rises in the permanent water table is a secondary option.

b. Groundwater Control Systems.

(1) Permanent Water Table. Because of a longer period of record for piezometers in the permanent water table at the FY 86 landfill, a system to control a rise in the permanent water table is not considered necessary. The landfill cells will be designed such that the bottom of the clay liner will be 10 feet above the highest recorded level of the permanent water table, as shown on the geologic sections on plate X-35.

(2) Perched Water Table Control. There is a significant perched water table at the landfill site during periods of wet weather. A system to control this water should be incorporated into the design of the landfill. A 2 foot wide french-drain to the top of the Jackson clay-shale around the landfill cels would serve the purpose of controlling the perched water. A low permeability material should cover the sand to keep surface water out of the system. A system which drains by gravity is desirable because of the need to keep maintenance to a minimum. A discharge point in the drainage close to the site would be acceptable since the water will not be contaminated.

c. Liner System. The liner system must consist of the following: (from the bottom up)

(1) Secondary Liner. The secondary liner should be a 3-foot thick clay layer with an in-situ saturated hydraulic conductivity of no greater than $1X10^{-7}$ cm/sec.

(2) Secondary Leachate Collection System. The secondary leachate collection system must be capable of maintaining a leachate head of one foot or less. Two options should be considered: 1) a 12-inch sand layer, with drainage pipes on a slope of at least 2% and a sump in the lowest point to collect leachate, and 2) a plastic drainage media with filter cloth protecting the underlying clay liner on a grade such that a maximum one foot of leachate head would be present on the secondary liner at any time and a sump to remove collected leachate. The standpipe(s) for this system should be provided within the landfill cell such that pipes are not placed through the clay liner. A "boot" should be provided around the standpipe(s) where they penetrate the synthetic liner.

(3) Primary Liner. The primary liner should consist of a synthetic liner at least 30 mils thick of demonstrated compatability with the waste to be stored.

(4) Primary Leachate Collection System. The primary leachate collection system should consist of either the sand layer with perforated pipes or the plastic drainage media covered with filter cloth as discussed in para. 5.c. (2). If plastic drainage media are used, the first 6" of waste must be soil no coarser than a SP sand to serve as a bedding layer.

d. Cover System. The cover system shall consist of 3 components:

(1) Low Permeability Bottom Layer. The low permeability bottom layer should consist of a 2-foot clay cover of maximum $1x10^{-7}$ cm/sec

saturated hydraulic conductivity covered by a synthetic liner of a minimum ... mil thickness.

(2) Middle Drainage Layer. The middle drainage layer can be either a sand layer with perforated pipe or a plastic drainage net with filter cloth coverning it (between drainage net and vegetated top cover). Discharge should flow freely laterally to minimize the head on the low permeability layer.

(3) Vegetated Top Cover. The vegetated top cover should consist of at least 2 feet of nonerosive soil capable of supporting vegetation. The final slope should be between 3 and 5 percent.

e. Raincover Footings. Raincover footings should rest entirely above the four components of the liner system. Because of the strength of the geotextile materials in the liner system, a maximum allowable bearing capacity of 1500 psf is recommended.

f. Liner Material. Although remolded permeability tests on samples from required excavation in the landfill areas yielded adequate permeabilities for liner material (see table 9), it is tentatively recommended that liner material be obtained from borrow areas outside the landfill area. Much of the overburden material at the landfill site is very silty (liquid limit less than 20) and would not be suitable. The Jackson clay shale has such a high liquid limit that the material will be unworkable and highly susceptible to dessication cracking. Adequate borrow is available on the Arsenal which will produce a higher quality liner.

BORROW SOURCES

1. Introduction. An estimated quantity of 300,000 cubic yards of low-permeability fill is required for construction of the FY 86 Hazardous Landfill/Closure Sites project at Pine Bluff Arsenal. Lesser amounts of topsoil and random materials will also be required. Since the historic sites and landfill are scattered over the Arsenal, it is desireable to have 2 or 3 borrow areas available on the Arsenal, located as close as possible to those sites needing fill. Eight areas were designated by Arsenal facilities personnel as available borrow areas and these were explored in the preliminary investigations. Based on results of preliminary investigations, three of the areas were selected for further study and possible use. These areas are discussed in paragraph 3, Site Discussions.

2. Quantity Requirements. About 200,000 cubic yards of low permeability (clay) material is required for construction of clay liners, caps, and cutoff trenches in the in-situ closure of historic hazardous waste sites. Table 10 lists fill requirements for individual sites. Another 100,000 cubic yards of low-permeability fill is required at the Hazardous Landfill for construction of clay liners and caps. About 35,000 cubic yards of material will be incorporated into slurry trenches and will ideally consist of a sand with 30 to 50% plastic fines. Studies will be performed to determine suitability of material from the slurry trench excavation for mixture with the slurry and backfill into the slurry trench.

TABLE 10

BORROW MATERIAL REQUIREMENTS

SITE	REQUIRED IMPERVIOUS QUANTITY (yd3)	REQUIRED SLURRY TRENCH BACKFILL QUANTITY (yd3)
4A	22,700	-0-
7B	20,700	11,000
7C	4,900	7,500
7D	10,700	7,500
16A	1,300	-0-
20A	53,400	-0-
23A	12,000	6,000
29	38,400	-0-
38	1,100	-0-
TOTALS	165,200	32,000

3. Site Discussions.

a. Eastwood Bayou.

(1) Site Description. This is a heavily wooded area in the northern part of the Arsenal. The elevation of the ground surface is approximately 217, with the water table at 202. Access to the area can be obtained either through Wintergreen Road borrow area and across a creek or from the north east boundary patrol road. Site location is shown on the Arsenal map, plate X-1.

(2) Investigations. 6 shallow (10-12ft) auger holes were drilled May of 1984. Materials was laboratory classified and natural water content was determined. One test pit was dug in June of 1983 and the material was classified in the field. Two peizometers were installed in the vicinity by Waterways Experiment Station (WES) and material from the borings was laboratory classified.

(3) Results. Material at the site consists of floodplain deposits of 0.1 to 3.5 feet of silt overlying a reddish brown to brown high plasticity fat clay (liquid limits 45-65) ranging from 4.5 to 10 feet thick. Beneath this material is a leaner light brown to gray clay with liquid limits in the 25-35 range. The fatter clay is recommended for use as low permeability fill in either the in-situ closure schemes or landfill liners and covers. An estimated quantity of 200,000 yd^3 of this clay material is present at this site.

b. Site 4 Borrow Area.

(1) Site Description. This is a heavily wooded area in the northeastern part of the Arsenal, southwest of 504th Street in the vicinity of contaminated Site 4. Approximate elevation of the area is 280, with radial drainage to the southwest and southeast. The water table is present at about elevation 270 and slopes steeply north. Access to the area is along 504th Street. Site location is shown on the Arsenal map, plate X-1.

(2) Investigation. 3 shallow auger holes were drilled in May of 84. Material was classified in a laboratory and natural water content was

ermined. Several shallow auger holes were drilled at nearby site 4A in 1984 in preliminary site closure investigations. Some laboratory ssifications were performed on soil samples from those borings. One WES ezometer was installed at the site and material was laboratory classified.

(3) Results. Material at the site consists of 1 to 3.5 feet of silt overlaying a lean clay layer 4 to 6 feet thick. The lean clay has liquid limits from 28 to 42. Beneath this is a fat clay of liquid limits 50 to 75, approximately 7 feet thick. Both the silts and lean clays have approximately 40% sand by weight, whereas the fat clays are 1-5% sand. The fat clay is geologically classified as shale of the Jackson formation. It is soft and workable and has the behavior and characteristics of soil. Both the lean and fat clay should serve as suitable materials for clay covers and cutoff trenches for in-situ closures for historic sites. It is not recommended for use as a clay liner in the hazardous waste landfill. An estimated quantity of 120,000 cubic yards of lean sandy clay is present at the site overlying 170,000 cubic yards of the fat clay.

c. Williams Road.

(1) Site Description. The Williams Road borrow area is a heavily wooded area in the southern part of the Arsenal. The site is located on either side of Williams Road, west of Warbritton Gate. Access to the area is along Williams Road. Site location is shown on the Arsenal map, plate X-1. Elevation of the site is approximately 232 and the water table is at about elevation 202.

(2) Investigations. Five shallow auger holes were drilled in May :1 .984. Material was laboratory classified and natural water content determined. Five piezometers were installed in this vicinity by WES and samples were laboratory classified.

(3) Results. Material at the site consists of approximately 3 feet of silt, underlain by 15 feet of clay. The clays are lean and sandy with liquid limits of 25-40. Both the silt and clays are terrace deposits. The clay is suitable for use as low permeability fill in clay caps and cutoff trenches in in-situ closures of the historic hazardous waste sites. It is not recommended for use as material for a clay liner or cover in the hazardous waste landfill. An estimated volume of 6,000,000 cubic yards of the lean clay is present.

GEOTECHNICAL BRANCH

ENGINEERING DIVISION

TULSA DISTRICT

CORPS OF ENGINEERS

AUGUST 1984

PRE-SCORE

REFERENCE 6

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT

REGION: 6
SITE NUMBER (to be assigned by Hq): AR710

GENERAL INSTRUCTIONS: Complete Sections I and III through XV of this form as completely as possible. Then use the information on this form to develop a Tentative Disposition (Section II). File this form in its entirety in the regional Hazardous Waste Log File. Be sure to include all appropriate Supplemental Reports in the file. Submit a copy of the forms to: U.S. Environmental Protection Agency; Site Tracking System; Hazardous Waste Enforcement Task Force (EN-335); 401 M St., SW; Washington, DC 20460.

I. SITE IDENTIFICATION

A. SITE NAME: PINE BLUFF ARSENAL
B. STREET (or other identifier): Hwy. 256, East of Hwy. 365
C. CITY: Pine Bluff
D. STATE: AR
E. ZIP CODE: 71611
F. COUNTY NAME: Jefferson

G. SITE OPERATOR INFORMATION
1. NAME: U.S. Army
2. TELEPHONE NUMBER: (501)541-3572
3. STREET: Hwy. 365
4. CITY: Pine Bluff
5. STATE: AR
6. ZIP CODE: 71611

H. REALTY OWNER INFORMATION (if different from operator of site)
1. NAME: Same
2. TELEPHONE NUMBER:
3. CITY:
4. STATE:
5. ZIP CODE:

I. SITE DESCRIPTION: U.S. Army arsenal with numerous disposal/storage sites for waste. See Attachment A for description of sites inspected by FIT.

J. TYPE OF OWNERSHIP
[X] 1. FEDERAL [ ] 2. STATE [ ] 3. COUNTY [ ] 4. MUNICIPAL [ ] 5. PRIVATE

II. TENTATIVE DISPOSITION (complete this section last)

A. ESTIMATE DATE OF TENTATIVE DISPOSITION (mo., day, & yr.):
B. APPARENT SERIOUSNESS OF PROBLEM
[ ] 1. HIGH [X] 2. MEDIUM [ ] 3. LOW [ ] 4. NONE

C. PREPARER INFORMATION
1. NAME: Thomas N. Smith Thos N Smith
2. TELEPHONE NUMBER: (214)742-4521
3. DATE (mo., day, & yr.): March 2, 1982

III. INSPECTION INFORMATION

A. PRINCIPAL INSPECTOR INFORMATION
1. NAME: Thomas N. Smith
2. TITLE: FIT-Geologist
3. ORGANIZATION: Ecology and Environment, Inc., 1509 Main St., Dallas, TX 75201
4. TELEPHONE NO. (area code & no.): (214)742-4521

B. INSPECTION PARTICIPANTS

1. NAME	2. ORGANIZATION	3. TELEPHONE NO.
Barry Nash	Ecology & Environment, Inc.	(214)742-4521
Jim Trusley	" "	"
Gene McDonald	" "	"

C. SITE REPRESENTATIVES INTERVIEWED (corporate officials, workers, residents)

1. NAME	2. TITLE & TELEPHONE NO.	3. ADDRESS
Thomas Shook	Environmental Coordinator (501)534-4600	PBA, Pine Bluff, AR 71611
Wendell Fortner	Engineer (501)541-3578	" " "
Ken Mazander	" "	" " "
Bill McDonald	" "	" " "
Dennis Green	Field Inspector (501)371-1701	ADPC&E, Little Rock, AR
Mike Bates	" "	" " "

REVIEWED BY (CHECK) DATE 10/4/82

Continued From Page 2

IV. SAMPLING INFORMATION (continued)

C. PHOTOS

1. TYPE OF PHOTOS: [X] a. GROUND [X] b. AERIAL

2. PHOTOS IN CUSTODY OF: EPA Region VI (See Attachments)

D. SITE MAPPED?

[X] YES. SPECIFY LOCATION OF MAPS. USGS White Hall Quadrangle (See Attachments)

E. COORDINATES

1. LATITUDE (deg.-min.-sec.): 34°19'17"N
2. LONGITUDE (deg.-min.-sec.): 92°05'55"W

V. SITE INFORMATION

A. SITE STATUS

- [X] 1. ACTIVE (Those industrial or municipal sites which are being used for waste treatment, storage, or disposal on a continuing basis, even if infrequently.)
- [ ] 2. INACTIVE (Those sites which no longer receive wastes.)
- [ ] 3. OTHER (specify): (Those sites that include such incidents like "midnight dumping" where no regular or continuing use of the site for waste disposal has occurred.)

B. IS GENERATOR ON SITE?

[ ] 1. NO [X] 2. YES (specify generator's four-digit SIC Code): 3483, 3489

C. AREA OF SITE (in acres): 12,800

D. ARE THERE BUILDINGS ON THE SITE? [ ] 1. NO [X] 2. YES (specify): Offices, Warehouses, Residences

VI. CHARACTERIZATION OF SITE ACTIVITY

Indicate the major site activity(ies) and details relating to each activity by marking 'X' in the appropriate boxes.

'X'	A. TRANSPORTER	'X'	B. STORER	'X'	C. TREATER	'X'	D. DISPOSER
X		X		X		X	
X	1. RAIL	X	1. PILE	X	1. FILTRATION	X	1. LANDFILL
	2. SHIP	X	2. SURFACE IMPOUNDMENT	X	2. INCINERATION		2. LANDFARM
	3. BARGE	X	3. DRUMS		3. VOLUME REDUCTION	X	3. OPEN DUMP
X	4. TRUCK	X	4. TANK, ABOVE GROUND		4. RECYCLING/RECOVERY	X	4. SURFACE IMPOUNDMENT
X	5. PIPELINE		5. TANK, BELOW GROUND		5. CHEM./PHYS./TREATMENT		5. MIDNIGHT DUMPING
	6. OTHER (specify): See Attachments		6. OTHER (specify): See Attachments		6. BIOLOGICAL TREATMENT	X	6. INCINERATION
					7. WASTE OIL REPROCESSING		7. UNDERGROUND INJECTION
					8. SOLVENT RECOVERY		8. OTHER (specify): See Attachments
					9. OTHER (specify): See Attachments		

E. SUPPLEMENTAL REPORTS: If the site falls within any of the categories listed below, Supplemental Reports must be completed. Indicate which Supplemental Reports you have filled out and attached to this form.

[X] 1. STORAGE [ ] 2. INCINERATION [X] 3. LANDFILL [X] 4. SURFACE IMPOUNDMENT [ ] 5. DEEP WELL
[ ] 6. CHEM/BIO/PHYS TREATMENT [ ] 7. LANDFARM [ ] 8. OPEN DUMP [ ] 9. TRANSPORTER [ ] 10. RECYCLOR/RECLAIMER

VII. WASTE RELATED INFORMATION

A. WASTE TYPE

[X] 1. LIQUID [X] 2. SOLID [X] 3. SLUDGE [ ] 4. GAS

B. WASTE CHARACTERISTICS

[X] 1. CORROSIVE [X] 2. IGNITABLE [ ] 3. RADIOACTIVE [X] 4. HIGHLY VOLATILE
[X] 5. TOXIC [X] 6. REACTIVE [X] 7. INERT [X] 8. FLAMMABLE
[ ] 9. OTHER (specify):

C. WASTE CATEGORIES

1. Are records of wastes available? Specify items such as manifests, inventories, etc. below.

Not for abandoned sites; records are available for active sites.

Continue On Reverse

Continued From Front

VIII. HAZARD DESCRIPTION (continued)

H. DAMAGE TO FLORA/FAUNA

I. FISH KILL

J. CONTAMINATION OF AIR

[X] K. NOTICEABLE ODORS

Noxious sulfuric fumes were encountered at site 7c.

[X] L. CONTAMINATION OF SOIL

Contaminated soils are known to exist at sites 7a, 7c, 7c, 10, 17, 20a, 20b, 24, and is suspected at site 12.

M. PROPERTY DAMAGE

 Continue On Page 7

Continued From Page 6

VIII. HAZARD DESCRIPTION (continued)

X N. FIRE OR EXPLOSION

Evidence of past fires was noticed at site 16a, and the possibility of fires exist at site 20b (see supplemental reports).

X O. SPILLS/LEAKING CONTAINERS/RUNOFF/STANDING LIQUID

Evidence of past spills were observed at sites 7a, and 20a (see supplemental reports).

☐ P. SEWER, STORM DRAIN PROBLEMS

☐ Q. EROSION PROBLEMS

☐ R. INADEQUATE SECURITY

☐ S. INCOMPATIBLE WASTES

Continued From Page 8

X. WATER AND HYDROLOGICAL DATA (continued)

F. LIST ALL DRINKING WATER WELLS WITHIN A 1/4 MILE RADIUS OF SITE

1. WELL	2. DEPTH (specify unit)	3. LOCATION (proximity to population/buildings)	4. NON-COMMUNITY (mark 'X')	5. COMMUNITY (mark 'X')
PBA	2,000 ft.	On-site*		X
		*These wells are at sufficient depths to be considered safe. These deep aquifers are not recharged on-site.		

G. RECEIVING WATER

1. NAME: Arkansas River

☐ 2. SEWERS ☒ 3. STREAMS/RIVERS

☐ 4. LAKES/RESERVOIRS ☐ 5. OTHER (specify):

6. SPECIFY USE AND CLASSIFICATION OF RECEIVING WATERS

Suitable for desirable species of fish, wildlife and other aquatic and semi-aquatic life, raw water source for public water supplies, secondary contact recreation, warm water fishery.

XI. SOIL AND VEGITATION DATA

LOCATION OF SITE IS IN:

☐ A. KNOWN FAULT ZONE ☐ B. KARST ZONE ☒ C. 100 YEAR FLOOD PLAIN ☐ D. WETLAND

☐ E. A REGULATED FLOODWAY ☐ F. CRITICAL HABITAT ☒ G. RECHARGE ZONE OR SOLE SOURCE AQUIFER

XII. TYPE OF GEOLOGICAL MATERIAL OBSERVED

Mark 'X' to indicate the type(s) of geological material observed and specify where necessary, the component parts.

'X'	A. OVERBURDEN	'X'	B. BEDROCK (specify below)	'X'	C. OTHER (specify below)
X	1. SAND	X	Pleistocene Alluvium, Arkansas River		
X	2. CLAY	X	" "		
X	3. GRAVEL	X	" "		

XIII. SOIL PERMEABILITY

☐ A. UNKNOWN ☐ B. VERY HIGH (100,000 to 1000 cm/sec.) ☒ C. HIGH (1000 to 10 cm/sec.)

☐ D. MODERATE (10 to 1 cm/sec.) ☐ E. LOW (.1 to .001 cm/sec.) ☐ F. VERY LOW (.001 to .00001 cm/sec.)

G. RECHARGE AREA

☒ 1. YES ☐ 2. NO 3. COMMENTS: Arkansas River alluvial aquifer is recharged throughout floodplain.

H. DISCHARGE AREA

☐ 1. YES ☒ 2. NO 3. COMMENTS:

I. SLOPE

1. ESTIMATE % OF SLOPE	2. SPECIFY DIRECTION OF SLOPE, CONDITION OF SLOPE, ETC.
10-15%	Northeast

J. OTHER GEOLOGICAL DATA

The site tests atop the alternating sands, clays, and gravels of the Arkansas River alluvial belt.

Continue On Reverse

ATTACHMENT A

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT SUPPLEMENT SHEET

Instruction - This sheet is provided to give additional information in explanation of a question on the form T2070-3.

Corresponding number on form	Additional Remark and/or Explanation
I.i.	
(#1) Site 16a White Phosphorus Settling Pond	Site 16a is the White Phosphorus Settling Pond and Landfill. The site has been closed and abandoned. During its operation, process water from the white phosphorus production area was directed to White Phosphorus Creek (now White Creek). This creek had a 20 x 40 foot concrete retention basin built into it to catch sludge from the White Phosphorus operation. As the sludge accumulated, it was dredged and dumped in a burning area. As white phosphorus ignites upon exposure to air, stabilization required that it be burned prior to burial. The burned material was then put in a diked area or berm and covered daily with up to 2 feet of soil. The present mound measures approximately 100 x 50 x 8 ft. covering an undetermined amount of waste. No final closure of this area ever occurred, but daily application of cover was standard procedure. A final closure of the retention pond has been accomplished and the creek diverted around the more severely contaminated areas. Although a 2 foot cover would seem adequate, evidence of past fires was noticed during the inspection. The source of the fire could not be attributed to the presence of white phosphorus, but the possibility does exist. Additional cover may be necessary.
(#2) Site 18a Sanitary Landfill	Site 18a is a current sanitary landfill. It is a permitted landfill which is in compliance with state regulations. No hazardous materials have been dumped here, although the rubber shell of a bouncing grenade was discovered on-site during the investigation. Due to the steepness of slope and lack of vegetative cover in areas, several erosional ravines gouge the landfill. Some of these gullies are 3 to 4 feet deep, although quite narrow. Further maintenance may be required at this site; however, there are no indications that hazardous wastes are disposed here.

ATTACHMENT A

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT SUPPLEMENT SHEET

Instruction - This sheet is provided to give additional information in explanation of a question on the form T2070-3.

Corresponding number on form	Additional Remark and/or Explanation
(#3) Site 18b Facilities Rubble Pile	Site 18b is an open dump for rubble originating from the demolition of buildings or other structures on Pine Bluff Arsenal. All materials are either cleaned or decontaminated before they are brought here. There is no evidence of the disposal of any liquids or hazardous materials; only wood, concrete, and asphalt was observed. Some of the demolished buildings originally contained hazardous materials. Although these were decontaminated prior to demolition and disposal at this site, a periodic check of the completeness of the decontamination procedure may be warranted due to the porous nature of the construction material.
(#4) Site 20b White Phosphorus Slag Burn Pit	Site 20b is an abandoned pit used for the disposal of white phosphorus. While in use, 50 gallon drums of white phosphorus, white phosphorus grenades, and other white phosphorus waste was dumped over the face of a cliff and burned. Analyses of the soil have indicated phosphorus levels of 8760 ppm of PO_4. During the inspection, piles of slag as well as drums and undetonated grenades were noted along the slopes and bottom of the valley. Due to the local topography, drainage through the site is inevitable. Ponded water was evident near the base of the dump area, and a large slough began just down gradient. This slough eventually reaches the Arkansas River. One surface soil sample was taken at this site. The analysis of this sample indicated a high concentration of lead (211 ppm). White phosphorus is considered a hazardous waste due to its characteristic of ignitability and toxicity. Due to its low solubility (1 part in 300,000) and the surficial hydrologic characteristics of the immediate area, groundwater contamination is not expected to be a major concern. The possibility for surface water contamination, as well as the possibility of fires during drought conditions, dictates the necessity for closure of this site. The AEHA recommends closure of the site in place. However, the removal of contaminated material followed by incineration and disposal at a hazardous landfill should also be investigated. Until closure operations are initiated, the FIT considers an imminent health hazard to exist at this site.

ATTACHMENT A

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT SUPPLEMENT SHEET

Instruction - This sheet is provided to give additional information in explanation of a question on the form T2070-3.

Corresponding number on form	Additional Remark and/or Explanation
(#5) Site 24 Thermite Waste Disposal Site Soil ppm cadmium 143 nickel 281 copper 2980 zinc 271 DDE 0.17 DDT 0.035 [illegible] Army [illegible] Item 26 [illegible] - [illegible] Section 2	Site 24 is an active four-acre disposal site for thermite waste from the drop test tower and lead oxide waste from the bomb washout facility. High concentration of lead (180 ppm), zinc (271 ppm), beryllilum (5-6 ppm), cadmium (143 ppm), chromium (1520 ppm), nickel (281 ppm), and copper (2980 ppm) were detected at the site. The majority of these metals are generally insoluble or only slightly soluble and the oxides can be poisonous as a dust. Chromium and cadmium form more soluble compounds and have been demonstrated to be toxic to aquatic life. One sediment sample was taken from the stream south and downstream from the site. Further monitoring of the streams that border the site may be necessary, particularly during rainfalls. Removal of the waste and subsequent disposal in a hazardous waste landfill should be considered.
(#6) Site 26 The Quality Assurance Drop Test Tower	Site 26 is a concrete lined basin used to test fire all types of smoke and thermite grenades. The basin is 30 feet on a side and 6 feet deep, according to arsenal reports. However, the basin appears to be only 6 inches deep. Residue consisting of corroded canisters and grenades covers the bottom to a depth of 2 to 16 inches. The basin drains to a sump 6 x 6 x 6 feet in measurement. Water which collects here is pumped to the central waste treatment area. In the past, solid wastes were either containerized and stored or dumped on the ground at site 24, the Thermite Waste Disposal area. Now the solid wastes are hauled to the incinerator complex. There is a small area adjacent to the drop tower (see photo 14) which appears to contain the same type rubble. This area is unlined and has no containment measures. No obvious run-off paths are visible. Debris in the basin and on the ground should be removed. If found to be hazardous, it should be disposed in a hazardous landfill. Groundwater contamination is a slight possibility due to the relatively shallow depth of the water table. Surface run-off may be a more likely path of contamination. That material which is not in the concrete basins should be addressed first.

ATTACHMENT A

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT SUPPLEMENT SHEET

Instruction - This sheet is provided to give additional information in explanation of a question on the form T2070-3.

Corresponding number on form	Additional Remark and/or Explanation
(#7) Site 29a Salt Pile	This is a 100 cubic yard salt pile located in the vicinity of an old chlorine manufacturing plant. The pile has been covered with asphalt to retard erosion and is non-hazardous as defined by RCRA. No imminent hazards exist at the site; however, it is recommended that the waste material be removed and landfilled to adequately close the site.
(#8) Site 31a Goat Shed Test Site Salt Zinc 1450 Trace Benzanthracenone	Site 31a is an abandoned smoke grenade test site. Although piles of waste material are not present, approximately one to two acres of ground is covered with residue from the smoke grenades and is devoid of vegetation. As is clearly evident from aerial photos and ground photos (#16, 17), erosional patterns and surface drainage are prevalent on-site. A sediment sample was collected by the FIT from an area just southwest of the site. Subsequent analysis of this sample showed high concentrations of zinc (1450 ppm) and lead (2818 ppm). On-site soils and sediments should be removed and taken to a hazardous waste landfill.
(#9) Site 31b Grenade Test Basin	The grenade test basin is a concrete lined basin which is used to test all types of smoke and thermite grenades. The basin is drained by a sump which directs run-off to the central waste treatment system. The drainage, at one time, flowed out into surface drainage paths, but this pathway has since been blocked. The site is still used on occasions. While in the past, residue removed from the pit was taken to the Thermite Waste Disposal area (site 24), the current practice is to haul excess residue to the incinerator complex. Proper maintenance of this area should eliminate any potential hazardous waste problem.

ATTACHMENT A

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT SUPPLEMENT SHEET

Instruction - This sheet is provided to give additional information in explanation of a question on the form T2070-3.

Corresponding number on form	Additional Remark and/or Explanation
(#10) Site 34 NCTR Equalization Pond	This site is a small equalization pond which was used by the National Center for Toxicological Research prior to June 1980. Sludge and water samples have been analyzed by the Army and are non-hazardous as defined by RCRA. No hazards were noted during the inspection and no future sampling is recommended.
(#11) Site 35 North Oxidation Pond	Site 35 is an active, unlined 70 acre foot oxidation pond. It is listed as outfall 001 on the Pine Bluff Arsenal NPDES permit and is currently in compliance with permit regulations. The pond handles domestic sewage from the National Center for Toxicological Research and the northern portion of the arsenal. No production waters are involved, and there is no evidence of any hazardous materials reaching this particular system. A chlorination system, checked daily by the facilities engineer on the arsenal, adds chlorine to the final effluent. This system does not automtically adjust for changes in flow, and must therefore be changed manually. The effluent travels about 4 miles before entering the Arkansas River. There is no evidence that any hazardous materials are being stored or disposed at this site.
(#12) Site 36 Industrial Sludge Lagoons	Site 36 consist of two lined lagoons, each having a capacity of approximately 4.6 million gallons. At present, only one lagoon is "on line" to receive wastewater. The water is "final treated water" which enters the lagoons to settle out solids. The lagoon has not been dredged, but future plans call for the disposal of the dried and treated sludge in a planned hazardous waste landfill. At the present time, the lagoons do not represent a potential hazard.
(#13) Site 37 South Oxidation Pond	Site 37 is an active, unlined oxidation pond which serves the southern end of Pine Bluff Arsenal. Only domestic wastes are accepted for this disposal system. The outfall passes through South Production Creek to the Arkansas River. There is no indication that hazardous wastes are stored in this pond.

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POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT SUPPLEMENT SHEET

Instruction - This sheet is provided to give additional information in explanation of a question on the form T2070-3.

Corresponding number on form	Additional Remark and/or Explanation
(#14) Site 39 Pine Bluff Oxidation Pond	Site is 39 is a 100 acre, unlined oxidation pond leased to the City of Pine Bluff. Access to the pond is not available from the arsenal. There is no indication that hazardous wastes are disposed here. Dennis Green of the Arkansas Department of Pollution Control and Ecology has inspected the facility frequently and found it to be in compliance with all applicable regulations.
(#15) Site 40 Incinerator Complex [illegible] collected - [illegible]	Site 40, the incinerator complex, presently consists of a test incinerator, deactivation furnace, and a chaingrate incinerator. A fluid bed incinerator will be on line in 1983. It is not the operation of the incinerators that is of interest in this report, but rather the disposal of wastes which have passed through the incinerators. A temporary storage yard has been constucted adjacent to the incinerator complex and it is here that waste materials accumulate. In a loosely organized fashion, those materials which have already passed through the incinerators are segregated from materials which have not yet been incinerated. There is also some segregation of salvagable materials. The open dumpsters (photo 29) contain material contaminated with white phosphorus. Ash from the incinerators contains cadmium and hexachloroethane. At the time of the inspection, no migration of contaminated materials was noted. However, open drums and dumpsters presented a possible means of migration. A small drainage ditch was therefore sampled downstream from the site. Subsequent analysis of this sample detected no significant contaminants.
(#16) Site 41 Future Hazardous Landfill	This is a future site for the new hazardous waste landfill. Permitting has not been completed and no construction has begun. No inspection was made on this facility. No supplemental form has been prepared for this site as it would be non-applicable.

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POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT SUPPLEMENT SHEET

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Corresponding number on form	Additional Remark and/or Explanation
(#17) Site 42 Backwash Pond	Site 42 is the backwash pond for the drinking water system. There is no industrial input. The overflow goes to central waste treatment. The sludge is pumped to drying beds at the sewage treatment plant. There is no indication of the presence of hazardous wastes and no indication of a potential hazard.
(#18) Site 43 White Phosphorus Pollution Abatement Facility	Site 43 (see photo 31) is an active facility for the dewatering of "phossy water" and air pollution control for the production of white phosphorus (elemental phosphorus). Due to the limited production of white phosphorus, the pollution abatement system has not accumulated enough wastes to initiate the disposal plan. Two operations lead to the generation of waste. The dewatering of "phossy water" leads to the generation of sodium phosphate salts. These salts will be drummed for disposal at the planned hazardous landfill. At present, there is insufficient accumulation to warrant disposal. Any excess water in this stage of the operation is sent to the Central Wastes Treatment Center. The second operation deals with air pollution control. At this stage, white phosphorus drops out as a slag while contaminated water goes to the Central Waste Treatment Center. The slag will be sent to the incinerator complex to be processsed by the liquid bed incinerator. At present, no slag has been sent to the incinerator complex, as insufficient quantities have built up to warrant disposal. The white phosphorus pollution abatement facility presently generates no hazardous material. During future operations of the facility, the proper operation of all components of the system will ensure the proper disposal of hazardous materials. No supplemental form has been prepared for this site as it would be non-appplicable.

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POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT SUPPLEMENT SHEET

Instruction - This sheet is provided to give additional information in explanation of a question on the form T2070-3.

Corresponding number on form	Additional Remark and/or Explanation
(#19) Site 7b Lewisite Disposal Site [illegible] arsenic 1700ppm mercury 72ppm	This is an abandoned 5-acre impoundment with two broken dams. A white limey sludge up to 5 feet thick covers the site and has begun to migrate downstream along Phillips Creek. Army analysis of this sludge yielded high concentrations of arsenic and selenium with measurable amounts of chromium and mercury. The analysis of a sample collected by the FIT confirmed the presence of arsenic (1700 ppm) and mercury (72 ppm) in significant concentrations. Approximately 420,000 cubic feet of the sludge lies exposed at the site. An imminent health hazard exists because of the contents and mobility of this sludge. The FIT recommends that the site be closed and secured immediately. Contaminated soils should be disposed in a hazardous landfill and monitoring wells should be installed around the site to determine if groundwater contamination has occurred.
(#20) Site 7c Mustard Burn Yard [illegible] [illegible] 188 [illegible]	This is a 1/2 acre site near the southeast corner of the toxic storage yard (site 7A) which was used as a burn yard for old mustard agents (See photos 34 & 35). Noxious fumes were encountered during the inspection and the soils were observed to be yellow to black. Army laboratory analyses indicated that these soils contain arsenic, chromium, mercury, zinc, and sulfates. The analysis of a sample collected by the FIT confirmed the presence of arsenic (188 ppm) and mercury (424 ppm) in significant concentrations. A tributary of Phillips Creek flows through this site and represents a potential pathway for contaminants to migrate into the Arkansas River. An imminent health hazard exists at this site due to the contaminated nature of the soils and their proximity to Phillips Creek. The FIT recommends that the site be closed and secured immediately. Contaminated soils should be disposed in a hazardous landfill and monitoring wells should be installed around the site to determine if groundwater contamination exists. No supplemental form has been prepared for this site as it would be non-applicable.
(#21) Site 10 Depot Burning and Demolition Area	This is an area of unsorted waste piles of drummed waste, ammunition packing crates and boxes, old ordnance shells, refuse, etc (See photos 36-39). Four open burning trenches and cages are located along the southwestern edge of the site.

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POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT SUPPLEMENT SHEET

Instruction - This sheet is provided to give additional information in explanation of a question on the form T2070-3.

Corresponding number on form	Additional Remark and/or Explanation
(Con't. of Site 10) Soil samples (ppm) [illegible] zinc 549 copper [illegible] cadmium [illegible] [illegible]chlo. [illegible] (PCB) 0.71	(Con't. of site 10) The FIT collected samples from two of these trenches. Subsequent analysis of these samples indicated high concentrations of arsenic (13.1 ppm), zinc (899 ppm), lead (120 ppm), cadmium (226 ppm), copper (560 ppm) and PCB-1254 (71 ppb). The army considers this area an "open dump" as defined by RCRA and recognizes the imminent health hazard it represents. However, no formal closure plans have been adopted. The FIT recommends that the site be closed and secured immediately. Contaminated soils should be disposed in a hazardous landfill and monitoring wells should be installed to determine if groundwater contamination has occurred.
(#22) Site 17 Product Assurance Test Range and Dump Site Soil zinc 153 Water aluminum 2050 iron 3140 manganese 150	This site was used for the testing of smoke grenades and the disposal of refuse materials such as expended smoke grenades and pyrotechnic devices. This refuse was deposited without cover along and down the escarpment which rims Yellow Lake. Army analysis of the residue and soil from the dump site showed evidence of explosive contaminants (2,4 DNT and 2,6 DNT) and cadmium. A sediment sample collected by the FIT from the base of the escarpment contained 153 ppm zinc. Yellow Lake collects all run-off from the dump site escarpment and is drained by an unnamed stream which flows directly into the Arkansas River. An aqueous sample was collected by the FIT from this stream (sample location 02). Subsequent analysis revealed the presence of 4,4 DDT and its metabolites, aluminum, manganese and arsenic. An imminent health hazard exists at this site due to the contaminated nature of the soils and their tributary link to the Arkansas River. The FIT recommends that this site be immediately closed and secured. Contaminated soils and wastes should be disposed in a hazardous landfill and monitoring wells should be installed around the site to determine if groundwater contamination has occurred. No supplemental form has been prepared for this site as it would be non-applicable.
(#23) Site 20a Depot South Burn Pit and Storage Area	This is an old burn and dump site for contaminated explosive materials and drummed miscellaneous waste. Other wastes (wood and metal) are stacked indiscriminately around the site (See photos 40-42). There is no evidence of past spills throughout

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POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT SUPPLEMENT SHEET

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(Con't. of Site 20a) Site / max 2100 250 manganese	(Con't. of site 20a) the site and there are no dikes around the perimeter. The area is bounded on the north by a swamp which collects the run-off and empties directly into the Arkansas River. Chemical analyses of the swamp alluvium and on-site soils indicated high amounts of explosives (RDX; 2,4 DNT; and 2,6 DNT) and lead. Barium and cadmium were detectable in small quantities. An aqueous sample collected by the FIT from this swamp indicated 250 ppb manganese. An imminent health hazard exists at this site due to the contaminated nature of the alluvium/soil and the proximity to the Arkansas River. The FIT recommends that the site be immediately closed and secured. Monitoring wells should be installed around the site to determine if groundwater contamination has occurred.
(#24) Site 38 Impregnite Sludge Lagoon	The impregnite sludge lagoon is an unlined pit, 30 x 30 x 15 feet deep, which received an impregnite and chloroethylene solvent stripper sludge after alum and lime flocculation treatment. Previous analyses have indicated low levels of cadmium and mercury. The pit was designed for one order, and has not been used in 3 or 4 years. The pit is quite near to being full. Future operation of the impregnite plant will use a system whereby the sludge will be hauled by truck to an incinerator rather than piping it to a settling pond. The aerial photos indicate that the sludge pit is drying out. At the time of the inspection, however, 3 to 4 inches of rain-water covered the pit. A drain system at one end of the pit (see photo 43) directs overflow to the central waste treatment system. A breach in the retaining wall at one corner of the pit is shown in photo 44. This breach is for an unknown purpose, being apparently man made. Close inspection indicated that the slope was towards the pit, so run-off is not expected to be a problem at this area. Groundwater contamination, however, remains a potential area of concern. The FIT, therefore, recommends that monitoring wells be installed around the pit to determine if groundwater contamination has occurred.
(#25) Site 7a Toxic Storage Yard	This is a 40-acre facility used to store hazardous materials and wastes (See photos 45-48). Numerous spills have occurred at this site due to container corrosion and an imminent hazard exists. The Army considers this storage yard an "open dump" and recognizes the need to

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POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT SUPPLEMENT SHEET

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(Con't. of Site 7a)	(con't. of site 7a) close the facility. However, no appropriations have been made to adequately secure the site. The FIT recommends that samples be taken from several erosional gullies along the southern boundary of the yard to determine the extent of off-facility contamination. Samples from nearby monitoring wells (WES wells No. 43, 62, 63, 64, 65, 80, and 81) should also be collected to ascertain whether or not current groundwater contamination exists.
(#26) Site 7d TSY Borrow Pits	This site consists of two abandoned borrow trenches south of the toxic storage yard (site 7a). The trenches are parallel and are filled with water. The north trench is an old disposal site for garbage and unknown materials. A spring which flows from the TSY (toxic storage yard) feeds the north pit and oxidizes the sediment to a rusty red color. Laboratory analysis of the sediment indicated the presence of As, Ba, Cd, Hg, and Zn; however, they were well below the hazardous levels as described by RCRA. An Army study has suggested that these pits be closed in place, capped with 18 inches of natural soil, and seeded with a resistant, fast-growing grass to retard erosion. It is recommended by the FIT that the water in these pits be sampled before any de-watering begins. A medium level of hazard should be assigned this site because of its close, downslope proximity to the toxic storage yard and the unknown chemical quality of its water.
(#27) Site 11a Sediment Retention Basin #1 (SRB-1)	This site is one of three sediment retention basins being used to capture run-off and DDT-contaminated sediment from an old DDT manufacturing facility. The sediments from these basins are currently being removed via dredging and placed into the DDT waste landfill (site 11f). No hazards were observed at this site during the inspection; however, samples of nearby monitoring wells (WES wells No. 43, 44, 45, 46, 53, 62, and 67) should be collected to determine if groundwater contamination currently exists.

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POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT SUPPLEMENT SHEET

Instruction - This sheet is provided to give additional information in explanation of a question on the form T2070-3.

Corresponding number on form	Additional Remark and/or Explanation
(#28) Site 11b Sediment Retention Basin #2 (SRB-2)	This site is one of three sediment retention basins being used to capture run-off and DDT-contaminated sediment from an old DDT manufacturing facility. The sediments from these basins are currently being removed via dredging and placed into the DDT waste landfill (site 11f). No hazards were observed at this site during the inspection; however, samples of nearby monitoring wells (WES wells No. 43, 44, 45, 46, 53, 62, and 67) should be collected to determine if groundwater contamination currently exists.
(#29) Site 11c Sediment Retention Basin #3 (SRB-3)	This site is one of three sediment retention basins being used to capture run-off and DDT-contaminated sediment from an old DDT manufacturing facility. The sediments from these basins are currently being removed via dredging and placed into the DDT waste landfill (site 11f). No hazards were observed at this site during the inspection; however; samples of nearby monitoring wells (WES wells No. 43, 44, 45, 46, 53, 62, and 67) should be collected to determine if groundwater contamination currently exists.
(#30) Site 11d DDT Storage in Basement, Bldg. 54-270	This is a storage area for crusty-DDT, the contaminated soils from an old DDT manufacturing facility. This material is currently stored (in landfill fashion) in the basement of a partially-demolished building (see photo 57) and has a 2-foot clay cover. Approximately 15,000 cubic feet of DDT-contaminated soils lie buried within this site. No obvious hazards were noted during the inspection. However, sampling of nearby monitoring wells (WES wells No. 43, 44, 49, 46, 53, 62, and 67) is recommended to determine if current groundwater contamination exists.

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POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT SUPPLEMENT SHEET

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Corresponding number on form	Additional Remark and/or Explanation
(#31) Site 11e DDT Basement Storage, Bldg. 54-325	This is an storage area for crusty-DDT, the contaminated soils from an old DDT manufacturing facility. This material is currently stored (in landfill fashion) in the basement of a demolished building (see photo 58) and has a 2-foot clay cover. Approximately 23,100 cubic feet of DDT-contaminated soils lie buried within this site. No obvious hazards were noted during the inspection. However, sampling of nearby monitoring wells (WES wells No. 43, 44, 45, 46, 53, 62, and 67) is recommended to determine if current groundwater contamination exists.
(#32) Site 11f DDT Waste Landfill	This is a landfill area (see photo 59) used for the disposal of DDT-contaminated soils from an old DDT manufacturing facility and dredge spoil from the three sediment retention basins (sites 11a, 11b, and 11c). Approximately 325,000 cubic feet of material lies buried within the site. No erosional instability was observed and no surficial hazards were noted during the inspection. However, sampling of nearby monitoring wells (WES wells no. 43, 44, 45, 46, 53, 62, and 67) is recommended to determine if current groundwater contamination exists.
(#33) Site 12 Abandoned Mustard Burn Pits	This is an abandoned dump and burn site for mustard munitions. It is surrounded by a dense growth of vegetation and investigations have confirmed the existence of burned, exploded, unexploded, and very weathered mustard munitions (see photo 60). The area has, however, been treated with a super tropical bleach for decontamination purposes. Approximately 15,000 cubic feet of mustard munitons lie abandoned within the site. This area can be considered an open dump and requires further evaluation and investigation to determine its hazard. Therefore, the FIT recommends that several soil samples be collected from areas downslope of the waste material to deter-

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POTENTIAL HAZARDOUS WASTE SITE
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Corresponding number on form	Additional Remark and/or Explanation
(Con't. of Site 12)	(Con't. of site 12) mine the extent of surficial contamination. Monitoring wells should also be installed south and east of the site to ascertain whether current groundwater contamination exists. No supplemental form has been prepared for this site as it would be non-applicable.
(#34) Site 15 Sanitary Landfill	This is a closed sanitary landfill and DDT site (see photo 61). Approximately 150,000 cubic feet of material lies buried here. The site is currently in compliance with RCRA and no hazards were observed during the inspection. However, monitoring of WES wells No. 15 and 16 is recommended to ascertain whether current groundwater contamination exists.
(#35) Site 27 Agent BZ Pond	The Agent BZ pond is an unlined, 1/4 acre impoundment which received the following wastes; Agent BZ, impregnite, thermite and lead oxide (bomb washout of starter mix). Previous analyses of the sludge revealed high concentrations of lead and detectable concentrations of cadmium and barium. A variety of effluents have reached the pond. The wastewater from the agent BZ production facility was directed to this pond after an alkaline was added to destroy the compound. Washwater from the decontamination of the BZ plant was also placed into this pond. Subsequent operations yielded washwaters containing bomb washout of igniter material and impregnite sludges. The impregnite operation which lasted from 1972 and 1975 was the last active use of the pond. The pond is in an area of Pleistocene terrace deposits. An intermittent stream flows eastward just north of the pond. It was into this stream that the treated pond water was piped (see photo 63). Groundwater flow is to the east, and occurs about

ATTACHMENT A

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT SUPPLEMENT SHEET

Instruction - This sheet is provided to give additional information in explanation of a question on the form T2070-3.

Corresponding number on form	Additional Remark and/or Explanation
(Con't. of Site 27)	(Cont't. of site 27) 20 feet below the surface. Groundwater monitoring is necessary at this site. At present, one monitoring well is located east-northeast of the site. Upgradient and downgradient wells should be installed and monitored. In addition, the FIT recommends that samples be collected from the small stream north of the site be colled from the small stream north of the site (water/sediment, upstream & downstream) and checked for inorganics.
(#36) Site 23 White Smoke Test Pond [illegible] [illegible] - [illegible] [illegible]	The White Smoke test pond is an unlined pond used for testing white smoke grenades and smoke pots. In addition, materials relating to the testing of these products have been dumped here. Analyses of the materials by the arsenal has indicated high levels of cadmium, lead, and zinc. An inspection of the pond revealed a site littered with refuse from the testing process. The pond bottom was almost covered with spent grenades and smoke pots (see photos 64-65). In addition the water was lifeless and had a pH of 5 to 5.5. A sediment sample was taken from the drainage area southwest of the pond. Subsequent analysis of this sample showed 185 ppm zinc. Since the pond is unlined, a potential exists for groundwater contamination. Further monitoring of the waste characteristics and water chemistry may be necessary to fully determine the extent of the hazard at this site. The FIT therefore recommends that an aqeuous sample be collected from the pond to determine this potential. Monitoring wells should also be installed around the pond to ascertain whether groundwater contamination has occurred.

Site 16a - White Pl ɔphorus Settling Pond (#1)

LANDFILLS SITE INSPECTION REPORT
(Supplemental Report)

INSTRUCTION
Answer and Explain as Necessary.

1. EVIDENCE OF SITE INSTABILITY *(Erosion, Settling, Sink Holes, etc)*
☐ YES ☒ NO See photo's 1-2

2. EVIDENCE OF IMPROPER DISPOSAL OF BULK LIQUIDS, SEMI-SOLIDS AND SLUDGES INTO THE LANDFILL
☐ YES ☒ NO

3. CHECK RECORDS OF CELL LOCATION AND CONTENTS AND BENCHMARK
☐ YES ☒ NO

4. WASTES SURROUNDED BY SORBENT MATERIAL
☐ YES ☒ NO

5. DIVERSION STRUCTURES ARE EFFECTIVELY CONSTRUCTED AND PROPERLY MAINTAINED
☒ YES ☐ NO

6. EVIDENCE OF PONDING OF WATER ON SITE
☐ YES ☒ NO

7. EVIDENCE OF IMPROPER/INADEQUATE DRAINING
☐ YES ☒ NO

8. ADEQUATE LEACHATE COLLECTION SYSTEM *(If "Yes", specify Type)*
☐ YES ☒ NO No leachate expected for this type of waste

8a. SURFACE LEACHATE SPRING
☐ YES ☒ NO

9. RECORDS OF LEACHATE ANALYSIS
☐ YES ☒ NO

10. GAS MONITORING
☐ YES ☒ NO

11. GROUNDWATER MONITORING WELLS
☒ YES ☐ NO Not specifically related to this site

12. ARTIFICIAL MEMBRANE LINER INSTALLED
☐ YES ☒ NO

13. SPECIFIC CONTAINMENT MEASURES *(Clay Bottom, Sides, etc)*
☒ YES ☐ NO Local clay soil bottom

14. FIXATION *(Stabilization)* OF WASTE
☒ YES ☐ NO White phosphorus was burned before covering

15. ADEQUATE CLOSURE OF INACTIVE PORTION OF FACILITY
☒ YES ☐ NO

16. COVER *(Type)*
Local soil

16a. THICKNESS
2 feet

16b. PERMEABILITY
Moderate

16c. DAILY APPLICATION
☒ YES ☐ NO

LANDFILLS SITE INSPECTION REPORT
(Supplemental Report)

INSTRUCTION
Answer and Explain as Necessary.

1. EVIDENCE OF SITE INSTABILITY *(Erosion, Settling, Sink Holes, etc)*
[X] YES [ ] NO See photo's 3-4. Deep (up to 4 ft.) channels have eroded away

2. EVIDENCE OF IMPROPER DISPOSAL OF BULK LIQUIDS, SEMI-SOLIDS AND SLUDGES INTO THE LANDFILL
[ ] YES [X] NO

3. CHECK RECORDS OF CELL LOCATION AND CONTENTS AND BENCHMARK
[ ] YES [X] NO

4. WASTES SURROUNDED BY SORBENT MATERIAL
[ ] YES [X] NO

5. DIVERSION STRUCTURES ARE EFFECTIVELY CONSTRUCTED AND PROPERLY MAINTAINED
[ ] YES [X] NO Run-off follows natural contours

6. EVIDENCE OF PONDING OF WATER ON SITE
[ ] YES [X] NO

7. EVIDENCE OF IMPROPER/INADEQUATE DRAINING
[X] YES [ ] NO Steep slopes have severe erosion problem

8. ADEQUATE LEACHATE COLLECTION SYSTEM *(If "Yes", specify Type)*
[ ] YES [X] NO None

8a. SURFACE LEACHATE SPRING
[ ] YES [X] NO

9. RECORDS OF LEACHATE ANALYSIS
[ ] YES [X] NO

10. GAS MONITORING
[ ] YES [X] NO

11. GROUNDWATER MONITORING WELLS
[X] YES [ ] NO Not specifically related to landfill

12. ARTIFICIAL MEMBRANE LINER INSTALLED
[ ] YES [X] NO

13. SPECIFIC CONTAINMENT MEASURES *(Clay Bottom, Sides, etc)*
[X] YES [ ] NO Local clay in soil

14. FIXATION *(Stabilization)* OF WASTE
[X] YES [ ] NO

15. ADEQUATE CLOSURE OF INACTIVE PORTION OF FACILITY
[X] YES [ ] NO

16. COVER *(Type)*

Local soil

16a. THICKNESS
24 to 36 inches

16b. PERMEABILITY

Moderate to high permeability

16c. DAILY APPLICATION
[X] YES [ ] NO

18b - Facilities RuL e Pile (#3)

STORAGE FACILITIES SITE INSPECTION REPORT
(Supplemental Report)

INSTRUCTION
Answer and Explain as Necessary.

1 STORAGE AREA HAS CONTINUOUS IMPERVIOUS BASE
[ ] YES [X] NO

2 STORAGE AREA HAS A CONFINEMENT STRUCTURE
[ ] YES [X] NO

3. EVIDENCE OF LEAKAGE/OVERFLOW *(If "Yes", document where and how much runoff is overflowing or leaking from containment)*
[ ] YES [X] NO No liquid materials are stored here. The area is a rubble pile where concrete, asphalt, and wood from the destruction of buildings is piled. Buildings which may have contained hazardous materials were decontaminated before demolition.

4. ESTIMATE TYPE AND NUMBER OF BARRELS/CONTAINERS
None

5. GLASS OR PLASTIC STORAGE CONTAINERS USED
[ ] YES [X] NO

6. ESTIMATE NUMBER AND CAPACITY OF STORAGE TANKS
None. Approximately 2,000 tons of rubber on-site. See photo 5

7. NOTE LABELING ON CONTAINERS
N/A

8. EVIDENCE OF LEAKAGE CORROSION OR BULGING OF BARRELS/CONTAINERS/STORAGE TANKS *(If "Yes", document evidence. Describe location and extent of damage. Take PHOTOGRAPHS)*
[ ] YES [X] NO

9. DIRECT VENTING OF STORAGE TANKS
[ ] YES [X] NO

10. CONTAINERS HOLDING INCOMPATIBLE SUBSTANCES *(If "Yes", document evidence. Describe location and identity of hazardous waste. Take PHOTOGRAPHS.)*
[ ] YES [X] NO

11. INCOMPATIBLE SUBSTANCES STORED IN CLOSE PROXIMITY *(If "Yes", document evidence. Describe location and identity of hazardous waste. Take PHOTOGRAPHS.)*
[ ] YES [X] NO

12. ADEQUATE CONTAINER WASHING AND REUSE PRACTICES
[ ] YES [ ] NO N/A

13. ADEQUATE PRACTICES FOR DISPOSAL OF EMPTY STORAGE CONTAINERS
[ ] YES [ ] NO N/A

Site 20b - Wh Phosphorus Slag Burn Pit (#4)

LANDFILLS SITE INSPECTION REPORT
(Supplemental Report)

INSTRUCTION
Answer and Explain as Necessary.

1. EVIDENCE OF SITE INSTABILITY *(Erosion, Settling, Sink Holes, etc)*
[X] YES [ ] NO Erosion on banks

2. EVIDENCE OF IMPROPER DISPOSAL OF BULK LIQUIDS, SEMI-SOLIDS AND SLUDGES INTO THE LANDFILL
[X] YES [ ] NO White phosphorus was burned here. Some unburned residue remains.

3. CHECK RECORDS OF CELL LOCATION AND CONTENTS AND BENCHMARK
[ ] YES [X] NO

4. WASTES SURROUNDED BY SORBENT MATERIAL
[ ] YES [X] NO

5. DIVERSION STRUCTURES ARE EFFECTIVELY CONSTRUCTED AND PROPERLY MAINTAINED
[ ] YES [X] NO

6. EVIDENCE OF PONDING OF WATER ON SITE
[X] YES [ ] NO

7. EVIDENCE OF IMPROPER/INADEQUATE DRAINING
[X] YES [ ] NO

8. ADEQUATE LEACHATE COLLECTION SYSTEM *(If "Yes", specify Type)*
[ ] YES [X] NO

8a. SURFACE LEACHATE SPRING
[ ] YES [X] NO

9. RECORDS OF LEACHATE ANALYSIS
[ ] YES [X] NO

10. GAS MONITORING
[ ] YES [X] NO

11. GROUNDWATER MONITORING WELLS
[ ] YES [X] NO

12. ARTIFICIAL MEMBRANE LINER INSTALLED
[ ] YES [X] NO

13. SPECIFIC CONTAINMENT MEASURES *(Clay Bottom, Sides, etc)*
[ ] YES [X] NO

14. FIXATION *(Stabilization)* OF WASTE White phosphorus was burned in place. However, evidence of
[X] YES [ ] NO unexploded grenades was found. See photo's 6-8.

15. ADEQUATE CLOSURE OF INACTIVE PORTION OF FACILITY
[ ] YES [X] NO

16. COVER *(Type)*
None

16a. THICKNESS
None

16b. PERMEABILITY
N/A

16c. DAILY APPLICATION
[ ] YES [X] NO

Site 24 - T!   nite Waste Disposal (#5)

STORAGE FACILITIES SITE INSPECTION REPORT (Supplemental Report)	INSTRUCTION Answer and Explain as Necessary.

1 STORAGE AREA HAS CONTINUOUS IMPERVIOUS BASE

[ ] YES [X] NO

2 STORAGE AREA HAS A CONFINEMENT STRUCTURE

[ ] YES [X] NO

3. EVIDENCE OF LEAKAGE/OVERFLOW *(If "Yes", document where and how much runoff is overflowing or leaking from containment)*

[X] YES [ ] NO Drainage paths through the site are evident (see photo's 10, 11).

4. ESTIMATE TYPE AND NUMBER OF BARRELS/CONTAINERS

None

5. GLASS OR PLASTIC STORAGE CONTAINERS USED

[ ] YES [X] NO

6. ESTIMATE NUMBER AND CAPACITY OF STORAGE TANKS

None-approximately 1,000 $ft.^3$ of material piled and spread over 4 acre site.

7. NOTE LABELING ON CONTAINERS

None

8. EVIDENCE OF LEAKAGE CORROSION OR BULGING OF BARRELS/CONTAINERS/STORAGE TANKS *(If "Yes", document evidence. Describe location and extent of damage. Take PHOTOGRAPHS)*

[ ] YES [X] NO

9. DIRECT VENTING OF STORAGE TANKS

[ ] YES [X] NO

10. CONTAINERS HOLDING INCOMPATIBLE SUBSTANCES *(If "Yes", document evidence. Describe location and identity of hazardous waste. Take PHOTOGRAPHS.)*

[ ] YES [X] NO

11. INCOMPATIBLE SUBSTANCES STORED IN CLOSE PROXIMITY *(If "Yes", document evidence. Describe location and identity of hazardous waste. Take PHOTOGRAPHS.)*

[ ] YES [X] NO

12. ADEQUATE CONTAINER WASHING AND REUSE PRACTICES

[ ] YES [ ] NO N/A

13. ADEQUATE PRACTICES FOR DISPOSAL OF EMPTY STORAGE CONTAINERS

[ ] YES [ ] NO N/A

Site 26 - Quality Assurance Drop Test Tower (#6)

STORAGE FACILITIES SITE INSPECTION REPORT
(Supplemental Report)

INSTRUCTION
Answer and Explain as Necessary.

1. STORAGE AREA HAS CONTINUOUS IMPERVIOUS BASE
[X] YES [ ] NO Storage is in a concrete basin

2. STORAGE AREA HAS A CONFINEMENT STRUCTURE
[X] YES [ ] NO Concrete dikes

3. EVIDENCE OF LEAKAGE/OVERFLOW *(If "Yes", document where and how much runoff is overflowing or leaking from containment)*
[X] YES [ ] NO An overflow of debris has occurred due to infrequent disposal of material. Also, an old test area nearby contains similar material spread on the ground. (See photo's 12-14)

4. ESTIMATE TYPE AND NUMBER OF BARRELS/CONTAINERS
None

5. GLASS OR PLASTIC STORAGE CONTAINERS USED
[ ] YES [X] NO

6. ESTIMATE NUMBER AND CAPACITY OF STORAGE TANKS
None. Approximately 2 tons of debris resulting from testing smoke grenades and canisters.

7. NOTE LABELING ON CONTAINERS
N/A

8. EVIDENCE OF LEAKAGE CORROSION OR BULGING OF BARRELS/CONTAINERS/STORAGE TANKS *(If "Yes", document evidence. Describe location and extent of damage. Take PHOTOGRAPHS)*
[ ] YES [X] NO

9. DIRECT VENTING OF STORAGE TANKS
[X] YES [ ] NO

10. CONTAINERS HOLDING INCOMPATIBLE SUBSTANCES *(If "Yes", document evidence. Describe location and identity of hazardous waste. Take PHOTOGRAPHS.)*
[ ] YES [X] NO

11. INCOMPATIBLE SUBSTANCES STORED IN CLOSE PROXIMITY *(If "Yes", document evidence. Describe location and identity of hazardous waste. Take PHOTOGRAPHS.)*
[ ] YES [X] NO

12. ADEQUATE CONTAINER WASHING AND REUSE PRACTICES
[ ] YES [ ] NO N/A

13. ADEQUATE PRACTICES FOR DISPOSAL OF EMPTY STORAGE CONTAINERS
[ ] YES [ ] NO N/A

Site 29A - Salt Pile (Open Dump) (#1)

STORAGE FACILITIES SITE INSPECTION REPORT
(Supplemental Report)

INSTRUCTION
Answer and Explain as Necessary.

1. STORAGE AREA HAS CONTINUOUS IMPERVIOUS BASE
☐ YES ☒ NO 100 cubic yd. salt pile covered w/asphalt to retard erosion.

2. STORAGE AREA HAS A CONFINEMENT STRUCTURE
☐ YES ☒ NO

3. EVIDENCE OF LEAKAGE/OVERFLOW *(If "Yes", document where and how much runoff is overflowing or leaking from containment)*
☐ YES ☒ NO

4. ESTIMATE TYPE AND NUMBER OF BARRELS/CONTAINERS
N/A

5. GLASS OR PLASTIC STORAGE CONTAINERS USED
☐ YES ☐ NO N/A

6. ESTIMATE NUMBER AND CAPACITY OF STORAGE TANKS
N/A

7. NOTE LABELING ON CONTAINERS
N/A

8. EVIDENCE OF LEAKAGE CORROSION OR BULGING OF BARRELS/CONTAINERS/STORAGE TANKS *(If "Yes", document evidence. Describe location and extent of damage. Take PHOTOGRAPHS)*
☐ YES ☐ NO N/A

9. DIRECT VENTING OF STORAGE TANKS
☐ YES ☐ NO N/A

10. CONTAINERS HOLDING INCOMPATIBLE SUBSTANCES *(If "Yes", document evidence. Describe location and identity of hazardous waste. Take PHOTOGRAPHS.)*
☐ YES ☐ NO
N/A

11. INCOMPATIBLE SUBSTANCES STORED IN CLOSE PROXIMITY *(If "Yes", document evidence. Describe location and identity of hazardous waste. Take PHOTOGRAPHS.)*
☐ YES ☒ NO

12. ADEQUATE CONTAINER WASHING AND REUSE PRACTICES
☐ YES ☐ NO N/A

13. ADEQUATE PRACTICES FOR DISPOSAL OF EMPTY STORAGE CONTAINERS
☐ YES ☐ NO N/A

Site 31a - Prouuct Assurance Test Site (Goat Sheu Test Site) (#8)

STORAGE FACILITIES SITE INSPECTION REPORT
(Supplemental Report)

INSTRUCTION
Answer and Explain as Necessary.

1. STORAGE AREA HAS CONTINUOUS IMPERVIOUS BASE
[ ] YES [X] NO

2. STORAGE AREA HAS A CONFINEMENT STRUCTURE
[ ] YES [X] NO

3. EVIDENCE OF LEAKAGE/OVERFLOW *(If "Yes", document where and how much runoff is overflowing or leaking from containment)*
[X] YES [ ] NO

Drainage path passes through contaminated area.

4. ESTIMATE TYPE AND NUMBER OF BARRELS/CONTAINERS
None. The productis covered with residue from smoke grenade testing.

5. GLASS OR PLASTIC STORAGE CONTAINERS USED
[ ] YES [X] NO

6. ESTIMATE NUMBER AND CAPACITY OF STORAGE TANKS
None

7. NOTE LABELING ON CONTAINERS
N/A

8. EVIDENCE OF LEAKAGE CORROSION OR BULGING OF BARRELS/CONTAINERS/STORAGE TANKS *(If "Yes", document evidence. Describe location and extent of damage. Take PHOTOGRAPHS)*
[ ] YES [X] NO

9. DIRECT VENTING OF STORAGE TANKS
[ ] YES [X] NO

10. CONTAINERS HOLDING INCOMPATIBLE SUBSTANCES *(If "Yes", document evidence. Describe location and identity of hazardous waste. Take PHOTOGRAPHS.)*
[ ] YES [X] NO

11. INCOMPATIBLE SUBSTANCES STORED IN CLOSE PROXIMITY *(If "Yes", document evidence. Describe location and identity of hazardous waste. Take PHOTOGRAPHS.)*
[ ] YES [X] NO

12. ADEQUATE CONTAINER WASHING AND REUSE PRACTICES
[ ] YES [ ] NO N/A

13. ADEQUATE PRACTICES FOR DISPOSAL OF EMPTY STORAGE CONTAINERS
[ ] YES [ ] NO N/A

Site - 31b Grenade Test Basin (#9)

STORAGE FACILITIES SITE INSPECTION REPORT (Supplemental Report)	INSTRUCTION Answer and Explain as Necessary.

1. STORAGE AREA HAS CONTINUOUS IMPERVIOUS BASE
[X] YES [ ] NO Concrete lined basin

2. STORAGE AREA HAS A CONFINEMENT STRUCTURE
[X] YES [ ] NO Basin is 6 feet deep, but filled to overflowing in spots.

3. EVIDENCE OF LEAKAGE/OVERFLOW *(If "Yes", document where and how much runoff is overflowing or leaking from containment)*
[X] YES [ ] NO
Material is not liquid, but solid residue from test firing smoke and thermite grenades.

4. ESTIMATE TYPE AND NUMBER OF BARRELS/CONTAINERS
None - 1,000 to 1,500 cubic feet of residue on-site.

5. GLASS OR PLASTIC STORAGE CONTAINERS USED
[X] YES [ ] NO

6. ESTIMATE NUMBER AND CAPACITY OF STORAGE TANKS
None. One concrete basin, 30' x 30' x 6'.

7. NOTE LABELING ON CONTAINERS
N/A

8. EVIDENCE OF LEAKAGE CORROSION OR BULGING OF BARRELS/CONTAINERS/STORAGE TANKS *(If "Yes", document evidence. Describe location and extent of damage. Take PHOTOGRAPHS)*
[X] YES [ ] NO

Although containment basin is in generally good condition, overflow has occurred (see photo 18).

9. DIRECT VENTING OF STORAGE TANKS
[X] YES [ ] NO

10. CONTAINERS HOLDING INCOMPATIBLE SUBSTANCES *(If "Yes", document evidence. Describe location and identity of hazardous waste. Take PHOTOGRAPHS.)*
[ ] YES [X] NO

11. INCOMPATIBLE SUBSTANCES STORED IN CLOSE PROXIMITY *(If "Yes", document evidence. Describe location and identity of hazardous waste. Take PHOTOGRAPHS.)*
[ ] YES [X] NO

12. ADEQUATE CONTAINER WASHING AND REUSE PRACTICES
[ ] YES [ ] NO N/A

13. ADEQUATE PRACTICES FOR DISPOSAL OF EMPTY STORAGE CONTAINERS
[ ] YES [ ] NO N/A

Site 34 NCTR Equalization Pond (#10)

SURFACE IMPOUNDMENTS SITE INSPECTION REPORT (Supplemental Report)	INSTRUCTION Answer and Explain as Necessary.

1. TYPE OF IMPOUNDMENT

Earthen. See photo 19

2. STABILITY/CONDITION OF EMBANKMENTS

Good

3. EVIDENCE OF SITE INSTABILITY *(Erosion, Settling, Sink Holes, etc.)*

[ ] YES [X] NO

4. EVIDENCE OF DISPOSAL OF IGNITABLE OR REACTIVE WASTE

[ ] YES [X] NO

5. ONLY COMPATIBLE WASTES ARE STORED OR DISPOSED OF IN THE IMPOUNDMENT

[X] YES [ ] NO

6. RECORDS CHECKED FOR CONTENTS AND LOCATION OF EACH SURFACE IMPOUNDMENT

[X] YES [ ] NO

7. IMPOUNDMENT HAS LINER SYSTEM

[ ] YES [X] NO

7a. INTEGRITY OF LINER SYSTEM CHECKED

[X] YES [ ] NO

7b. FINDINGS

No Liner

8. SOIL STRUCTURE AND SUBSTRUCTURE

Clay soil with sandy clay substrate

9. MONITORING WELLS

[X] YES [ ] NO Wells are in the area; however, none are site specific

10. LENGTH, WIDTH, AND DEPTH

LENGTH 175 ft. WIDTH 175 ft. DEPTH 9 ft.

11. CALCULATED VOLUMETRIC CAPACITY

276,000 cubic feet

12. PERCENT OF CAPACITY REMAINING

55%

13. ESTIMATE FREEBOARD

5 feet

14. SOLIDS DEPOSITION

[ ] YES [X] NO

15. DREDGING DISPOSAL METHOD

None

16. OTHER EQUIPMENT

N/A

EPA Form T2070-3C (10-79)

Site 35 - North Oxidation Pond (#11)

SURFACE IMPOUNDMENTS SITE INSPECTION REPORT (Supplemental Report)	INSTRUCTION Answer and Explain as Necessary.

1. TYPE OF IMPOUNDMENT
Earthen oxidation pond. See photo 20

2. STABILITY/CONDITION OF EMBANKMENTS
Excellent

3. EVIDENCE OF SITE INSTABILITY *(Erosion, Settling, Sink Holes, etc.)*
☐ YES ☒ NO

4. EVIDENCE OF DISPOSAL OF IGNITABLE OR REACTIVE WASTE
☐ YES ☒ NO

5. ONLY COMPATIBLE WASTES ARE STORED OR DISPOSED OF IN THE IMPOUNDMENT
☒ YES ☐ NO

6. RECORDS CHECKED FOR CONTENTS AND LOCATION OF EACH SURFACE IMPOUNDMENT
☒ YES ☐ NO

7. IMPOUNDMENT HAS LINER SYSTEM
☐ YES ☒ NO

7a. INTEGRITY OF LINER SYSTEM CHECKED
☐ YES ☐ NO N/A

7b. FINDINGS
N/A

8. SOIL STRUCTURE AND SUBSTRUCTURE
Clay soil with sandy clay substrate

9. MONITORING WELLS
☒ YES ☐ NO Not related to ox. pond

10. LENGTH, WIDTH, AND DEPTH
LENGTH 1750 ft. WIDTH 350 ft. DEPTH 5 ft.

11. CALCULATED VOLUMETRIC CAPACITY
70 acre feet

12. PERCENT OF CAPACITY REMAINING
System is steady state. 6 to 10% capacity remains to 2 ft. freeboard.

13. ESTIMATE FREEBOARD
Greater than 3 ft.

14. SOLIDS DEPOSITION
☒ YES ☐ NO

15. DREDGING DISPOSAL METHOD
Majority of solids removed at clarifier. Ox. pond is not dredged.

16. OTHER EQUIPMENT
Chlorination system at outfall. System at present is not automatic and is set manually daily. (See photo 12)

SURFACE IMPOUNDMENTS SITE INSPECTION REPORT
(Supplemental Report)

INSTRUCTION
Answer and Explain as Necessary.

1. TYPE OF IMPOUNDMENT
Industrial Sludge Lagoon (earthen) See photo 22

2. STABILITY/CONDITION OF EMBANKMENTS
Stable with excellent growth on banks

3. EVIDENCE OF SITE INSTABILITY *(Erosion, Settling, Sink Holes, etc.)*
☐ YES ☒ NO

4. EVIDENCE OF DISPOSAL OF IGNITABLE OR REACTIVE WASTE
☐ YES ☒ NO

5. ONLY COMPATIBLE WASTES ARE STORED OR DISPOSED OF IN THE IMPOUNDMENT
☒ YES ☐ NO

6. RECORDS CHECKED FOR CONTENTS AND LOCATION OF EACH SURFACE IMPOUNDMENT
☒ YES ☐ NO

7. IMPOUNDMENT HAS LINER SYSTEM
☒ YES ☐ NO Unknown material

7a. INTEGRITY OF LINER SYSTEM CHECKED
☐ YES ☒ NO

7b. FINDINGS
N/A

8. SOIL STRUCTURE AND SUBSTRUCTURE
Clay soil with sandy clay substrate

9. MONITORING WELLS
☒ YES ☐ NO Not specifically related to impoundments

10. LENGTH, WIDTH, AND DEPTH
LENGTH 500 ft. WIDTH 80 ft. DEPTH 15 ft.

11. CALCULATED VOLUMETRIC CAPACITY
4.6 million gallons for each of 2 impoundments

12. PERCENT OF CAPACITY REMAINING
Less than 5% in a steady state system

13. ESTIMATE FREEBOARD
18-24 inches

14. SOLIDS DEPOSITION
☒ YES ☐ NO

15. DREDGING DISPOSAL METHOD
Sludge will be dried, treated, and hauled to hazardous landfill when available

16. OTHER EQUIPMENT
At present, only one lagoon is operating as a sludge lagoon.

The other lagoon, although full of water, does not receive any wastewater.

Site 37 - S(h Oxidation Pond (#13)

SURFACE IMPOUNDMENTS SITE INSPECTION REPORT
(Supplemental Report)

INSTRUCTION
Answer and Explain as Necessary.

1. TYPE OF IMPOUNDMENT
Oxidation pond. See photo 23

2. STABILITY/CONDITION OF EMBANKMENTS
Excellent growth, stable banks

3. EVIDENCE OF SITE INSTABILITY *(Erosion, Settling, Sink Holes, etc.)*
[ ] YES [X] NO

4. EVIDENCE OF DISPOSAL OF IGNITABLE OR REACTIVE WASTE
[ ] YES [X] NO

5. ONLY COMPATIBLE WASTES ARE STORED OR DISPOSED OF IN THE IMPOUNDMENT
[X] YES [ ] NO

6. RECORDS CHECKED FOR CONTENTS AND LOCATION OF EACH SURFACE IMPOUNDMENT
[X] YES [ ] NO

7. IMPOUNDMENT HAS LINER SYSTEM
[ ] YES [X] NO

7a. INTEGRITY OF LINER SYSTEM CHECKED
[ ] YES [ ] NO N/A

7b. FINDINGS
N/A

8. SOIL STRUCTURE AND SUBSTRUCTURE
Clay soil with sandy clay substrate

9. MONITORING WELLS
[X] YES [ ] NO Not specifically related to ox. pond

10. LENGTH, WIDTH, AND DEPTH
LENGTH 420 ft. WIDTH 370 ft. DEPTH 6 ft.

11. CALCULATED VOLUMETRIC CAPACITY
19 acre feet

12. PERCENT OF CAPACITY REMAINING
Steady state system - 5-10% capacity remaining

13. ESTIMATE FREEBOARD
24-36 inches

14. SOLIDS DEPOSITION
[X] YES [ ] NO

15. DREDGING DISPOSAL METHOD
None-most solids removed prior to entry into ox. pond.

16. OTHER EQUIPMENT
Chlorinator system

Site 39 - P Bluff Oxidation Pond (#14)

SURFACE IMPOUNDMENTS SITE INSPECTION REPORT (Supplemental Report)	INSTRUCTION Answer and Explain as Necessary.

1. TYPE OF IMPOUNDMENT

Oxidation pond. See photo 24

2. STABILITY/CONDITION OF EMBANKMENTS

Stable and at least 15 feet wide at top. Excellent cover growth.

3. EVIDENCE OF SITE INSTABILITY *(Erosion, Settling, Sink Holes, etc.)*

☐ YES ☒ NO

4. EVIDENCE OF DISPOSAL OF IGNITABLE OR REACTIVE WASTE

☐ YES ☒ NO

5. ONLY COMPATIBLE WASTES ARE STORED OR DISPOSED OF IN THE IMPOUNDMENT

☒ YES ☐ NO

6. RECORDS CHECKED FOR CONTENTS AND LOCATION OF EACH SURFACE IMPOUNDMENT

☒ YES ☐ NO

7. IMPOUNDMENT HAS LINER SYSTEM

☐ YES ☒ NO

7a. INTEGRITY OF LINER SYSTEM CHECKED

☐ YES ☐ NO N/A

7b. FINDINGS

N/A

8. SOIL STRUCTURE AND SUBSTRUCTURE

Clay soil with sandy clay substrate.

9. MONITORING WELLS

☒ YES ☐ NO Not specifically related to ox. pond, wells are at periphery.

10. LENGTH, WIDTH, AND DEPTH

LENGTH 2875 ft. WIDTH 1,000 ft. DEPTH 15 ft.

11. CALCULATED VOLUMETRIC CAPACITY

1,000 acre ft.

12. PERCENT OF CAPACITY REMAINING

Less than 5%

13. ESTIMATE FREEBOARD

24 to 36 inches

14. SOLIDS DEPOSITION

☒ YES ☐ NO

15. DREDGING DISPOSAL METHOD

Unknown. Operated by City of Pine Bluff

16. OTHER EQUIPMENT

EPA Form T2070-3C (10-79)

Site 40 Incinerator Complex (#15)

STORAGE FACILITIES SITE INSPECTION REPORT (Supplemental Report)	INSTRUCTION Answer and Explain as Necessary.

1. STORAGE AREA HAS CONTINUOUS IMPERVIOUS BASE

[X] YES [ ] NO All containers are on an asphalt slab. See photo's 25, 26, 28 & 29.

2. STORAGE AREA HAS A CONFINEMENT STRUCTURE

[ ] YES [X] NO

3. EVIDENCE OF LEAKAGE/OVERFLOW *(If "Yes", document where and how much runoff is overflowing or leaking from containment)*

[ ] YES [X] NO No liquid wastes are kept here, except for minor amounts of laborabory waste. However, containers holding contaminated waste are in some cases exposed to air. Although visible run-off was not noted, the drainage path was sampled.

4. ESTIMATE TYPE AND NUMBER OF BARRELS/CONTAINERS

8 x 64 $ft.^3$ open dumpsters - 360 x 55 gallon drums.

5. GLASS OR PLASTIC STORAGE CONTAINERS USED

[ ] YES [X] NO

6. ESTIMATE NUMBER AND CAPACITY OF STORAGE TANKS

None

7. NOTE LABELING ON CONTAINERS

There is generally no current labelling.

8. EVIDENCE OF LEAKAGE CORROSION OR BULGING OF BARRELS/CONTAINERS/STORAGE TANKS *(If "Yes", document evidence. Describe location and extent of damage. Take PHOTOGRAPHS)*

[ ] YES [X] NO

9. DIRECT VENTING OF STORAGE TANKS

[X] YES [ ] NO Many drums and all dumpsters are open.

10. CONTAINERS HOLDING INCOMPATIBLE SUBSTANCES *(If "Yes", document evidence. Describe location and identity of hazardous waste. Take PHOTOGRAPHS.)*

[ ] YES [X] NO

11. INCOMPATIBLE SUBSTANCES STORED IN CLOSE PROXIMITY *(If "Yes", document evidence. Describe location and identity of hazardous waste. Take PHOTOGRAPHS.)*

[X] YES [ ] NO See photo 27. HCl and NaOH in close proximity, next to container labeled "Carcinogenic Waste Collection Bottle". This is an isolated instance and involves a small amount of material.

12. ADEQUATE CONTAINER WASHING AND REUSE PRACTICES

[X] YES [ ] NO Dumpsters are used for the same purpose.

13. ADEQUATE PRACTICES FOR DISPOSAL OF EMPTY STORAGE CONTAINERS

[X] YES [ ] NO Drums are held until hazardous landfill is complete.

EPA Form T2070-3D (10-79)

Site 42 - B .wash Pond (#17)

SURFACE IMPOUNDMENTS SITE INSPECTION REPORT *(Supplemental Report)*	INSTRUCTION Answer and Explain as Necessary.

1. TYPE OF IMPOUNDMENT

Backwash pond for drinking water system. See photo 30.

2. STABILITY/CONDITION OF EMBANKMENTS

Excellent. Pond consists of concrete basin.

3. EVIDENCE OF SITE INSTABILITY *(Erosion, Settling, Sink Holes, etc.)*

☐ YES ☒ NO

4. EVIDENCE OF DISPOSAL OF IGNITABLE OR REACTIVE WASTE

☐ YES ☒ NO

5. ONLY COMPATIBLE WASTES ARE STORED OR DISPOSED OF IN THE IMPOUNDMENT

☒ YES ☐ NO

6. RECORDS CHECKED FOR CONTENTS AND LOCATION OF EACH SURFACE IMPOUNDMENT

☒ YES ☐ NO

7. IMPOUNDMENT HAS LINER SYSTEM

☒ YES ☐ NO Concrete basin

7a. INTEGRITY OF LINER SYSTEM CHECKED

☐ YES ☒ NO

7b. FINDINGS

N/A

8. SOIL STRUCTURE AND SUBSTRUCTURE

Clay soil with sandy clay substrate

9. MONITORING WELLS

☐ YES ☒ NO

10. LENGTH, WIDTH, AND DEPTH

LENGTH 75 ft. WIDTH 60 ft. DEPTH 7 ft.

11. CALCULATED VOLUMETRIC CAPACITY

32,000 cubic feet

12. PERCENT OF CAPACITY REMAINING

55%

13. ESTIMATE FREEBOARD

3 1/2 to 4 feet

14. SOLIDS DEPOSITION

☒ YES ☐ NO

15. DREDGING DISPOSAL METHOD

Sludge is pumped to drying beds at sewage treatment plant.

16. OTHER EQUIPMENT

Overflows goes to central waste treatment area.

Site 7b - ⸤ /isite Disposal Site (#19)

SURFACE IMPOUNDMENTS SITE INSPECTION REPORT (Supplemental Report)	INSTRUCTION Answer and Explain as Necessary.

1. TYPE OF IMPOUNDMENT

Earthen. See photo's 32 & 33

2 STABILITY/CONDITION OF EMBANKMENTS

Badly eroded, dams have broken

3. EVIDENCE OF SITE INSTABILITY *(Erosion, Settling, Sink Holes, etc.)*

[X] YES [ ] NO Dams have broken and water has drained.

4. EVIDENCE OF DISPOSAL OF IGNITABLE OR REACTIVE WASTE

[ ] YES [X] NO

5 ONLY COMPATIBLE WASTES ARE STORED OR DISPOSED OF IN THE IMPOUNDMENT

[X] YES [ ] NO

6. RECORDS CHECKED FOR CONTENTS AND LOCATION OF EACH SURFACE IMPOUNDMENT

[X] YES [ ] NO

7. IMPOUNDMENT HAS LINER SYSTEM

[ ] YES [X] NO

7a. INTEGRITY OF LINER SYSTEM CHECKED

[X] YES [ ] NO

7b. FINDINGS

No liner

8. SOIL STRUCTURE AND SUBSTRUCTURE

Clay soil with silty clay substrate

9. MONITORING WELLS

[X] YES [ ] NO Wells are in the area but none are site specific.

10. LENGTH, WIDTH, AND DEPTH

LENGTH 700 ft. WIDTH 120 ft. DEPTH 5 ft.

11. CALCULATED VOLUMETRIC CAPACITY

420,000 cubic feet

12. PERCENT OF CAPACITY REMAINING

None

13. ESTIMATE FREEBOARD

N/A

14. SOLIDS DEPOSITION

[ ] YES [X] NO

15 DREDGING DISPOSAL METHOD

None

16. OTHER EQUIPMENT

N/A

EPA Form T2070-3C (10-79)

Site 10 - De Burning and Demolition Area (#21)

STORAGE FACILITIES SITE INSPECTION REPORT *(Supplemental Report)*	**INSTRUCTION** Answer and Explain as Necessary.
1. STORAGE AREA HAS CONTINUOUS IMPERVIOUS BASE ☐ YES ☒ NO	
2. STORAGE AREA HAS A CONFINEMENT STRUCTURE ☐ YES ☒ NO	
3. EVIDENCE OF LEAKAGE/OVERFLOW *(If "Yes", document where and how much runoff is overflowing or leaking from containment)* ☐ YES ☒ NO	
4. ESTIMATE TYPE AND NUMBER OF BARRELS/CONTAINERS 300-400 5 gallon cans	
5. GLASS OR PLASTIC STORAGE CONTAINERS USED ☐ YES ☒ NO	
6. ESTIMATE NUMBER AND CAPACITY OF STORAGE TANKS None	
7 NOTE LABELING ON CONTAINERS De-con agents	
8. EVIDENCE OF LEAKAGE CORROSION OR BULGING OF BARRELS/CONTAINERS/STORAGE TANKS *(If "Yes", document evidence. Describe location and extent of damage. Take PHOTOGRAPHS)* ☐ YES ☒ NO	
9. DIRECT VENTING OF STORAGE TANKS ☐ YES ☐ NO N/A	
10. CONTAINERS HOLDING INCOMPATIBLE SUBSTANCES *(If "Yes", document evidence. Describe location and identity of hazardous waste. Take PHOTOGRAPHS.)* ☐ YES ☒ NO	
11. INCOMPATIBLE SUBSTANCES STORED IN CLOSE PROXIMITY *(If "Yes", document evidence. Describe location and identity of hazardous waste. Take PHOTOGRAPHS.)* ☐ YES ☒ NO	
12. ADEQUATE CONTAINER WASHING AND REUSE PRACTICES ☐ YES ☒ NO	
13. ADEQUATE PRACTICES FOR DISPOSAL OF EMPTY STORAGE CONTAINERS ☐ YES ☒ NO	

Site 20a - Depot South Burn Pit and Storage Area (#23)

STORAGE FACILITIES SITE INSPECTION REPORT (Supplemental Report)	INSTRUCTION Answer and Explain as Necessary.

1. STORAGE AREA HAS CONTINUOUS IMPERVIOUS BASE
☐ YES ☒ NO

2. STORAGE AREA HAS A CONFINEMENT STRUCTURE
☐ YES ☒ NO

3. EVIDENCE OF LEAKAGE/OVERFLOW *(If "Yes", document where and how much runoff is overflowing or leaking from containment)*
☒ YES ☐ NO There is evidence of past spills throughout the site. See photo 41

4. ESTIMATE TYPE AND NUMBER OF BARRELS/CONTAINERS
400-500 55-gallon drums. See photo's 40-42

5. GLASS OR PLASTIC STORAGE CONTAINERS USED
☐ YES ☒ NO

6. ESTIMATE NUMBER AND CAPACITY OF STORAGE TANKS
None

7. NOTE LABELING ON CONTAINERS
De-con agents, pesticides, etc.

8. EVIDENCE OF LEAKAGE CORROSION OR BULGING OF BARRELS/CONTAINERS/STORAGE TANKS *(If "Yes", document evidence. Describe location and extent of damage. Take PHOTOGRAPHS)*
☐ YES ☒ NO

9. DIRECT VENTING OF STORAGE TANKS
☐ YES ☐ NO N/A

10. CONTAINERS HOLDING INCOMPATIBLE SUBSTANCES *(If "Yes", document evidence. Describe location and identity of hazardous waste. Take PHOTOGRAPHS.)*
☐ YES ☒ NO

11. INCOMPATIBLE SUBSTANCES STORED IN CLOSE PROXIMITY *(If "Yes", document evidence. Describe location and identity of hazardous waste. Take PHOTOGRAPHS.)*
☐ YES ☒ NO

12. ADEQUATE CONTAINER WASHING AND REUSE PRACTICES
☐ YES ☒ NO

13. ADEQUATE PRACTICES FOR DISPOSAL OF EMPTY STORAGE CONTAINERS
☐ YES ☒ NO

SURFACE IMPOUNDMENTS SITE INSPECTION REPORT
(Supplemental Report)

INSTRUCTION
Answer and Explain as Necessary.

1. TYPE OF IMPOUNDMENT

Impregnite sludge lagoon. See photo's 43 & 44

2. STABILITY/CONDITION OF EMBANKMENTS

Good

3. EVIDENCE OF SITE INSTABILITY *(Erosion, Settling, Sink Holes, etc.)*

☐ YES ☒ NO

4. EVIDENCE OF DISPOSAL OF IGNITABLE OR REACTIVE WASTE

☐ YES ☒ NO

5. ONLY COMPATIBLE WASTES ARE STORED OR DISPOSED OF IN THE IMPOUNDMENT

☒ YES ☐ NO

6. RECORDS CHECKED FOR CONTENTS AND LOCATION OF EACH SURFACE IMPOUNDMENT

☒ YES ☐ NO

7. IMPOUNDMENT HAS LINER SYSTEM

☐ YES ☒ NO

7a. INTEGRITY OF LINER SYSTEM CHECKED

☐ YES ☐ NO N/A

7b. FINDINGS

N/A

8. SOIL STRUCTURE AND SUBSTRUCTURE

Clay soil with sandy clay substrate

9. MONITORING WELLS

☒ YES ☐ NO Not specifically related to sludge lagoon.

10. LENGTH, WIDTH, AND DEPTH

LENGTH 30 ft. WIDTH 30 ft. DEPTH 15 ft. at max depth

11. CALCULATED VOLUMETRIC CAPACITY

Approximately 6,500 cubic feet

12. PERCENT OF CAPACITY REMAINING

Less then 5%

13. ESTIMATE FREEBOARD

18 inches. Liquid in pit at time of inspection was all rainwater.

14. SOLIDS DEPOSITION

☒ YES ☐ NO

15. DREDGING DISPOSAL METHOD Pit has never been dredged. In future sludge from the impregnite operation which in past was disposed of here will instead be taken to incinerator.

16. OTHER EQUIPMENT

Operation has not been in use for 3-4 years.

Any overflow (resulting from rainfall) is directed to the central waste treatment system (see photo 43).

Site 7a - Toxic Storage Yard (#25)

STORAGE FACILITIES SITE INSPECTION REPORT (Supplemental Report)	INSTRUCTION Answer and Explain as Necessary.

1. STORAGE AREA HAS CONTINUOUS IMPERVIOUS BASE
[ ] YES [X] NO

2. STORAGE AREA HAS A CONFINEMENT STRUCTURE
[ ] YES [X] NO

3. EVIDENCE OF LEAKAGE/OVERFLOW *(If "Yes", document where and how much runoff is overflowing or leaking from containment)*
[X] YES [ ] NO

The soil is stained in widely dispersed areas due to the numerous spills which have occurred at this site because of container corrosion.

4. ESTIMATE TYPE AND NUMBER OF BARRELS/CONTAINERS
17,500 55-gallon drums. See photo 46

5. GLASS OR PLASTIC STORAGE CONTAINERS USED
[ ] YES [X] NO

6. ESTIMATE NUMBER AND CAPACITY OF STORAGE TANKS
None

7. NOTE LABELING ON CONTAINERS

De-con agents, DDT

8. EVIDENCE OF LEAKAGE CORROSION OR BULGING OF BARRELS/CONTAINERS/STORAGE TANKS *(If "Yes", document evidence. Describe location and extent of damage. Take PHOTOGRAPHS)*
[X] YES [ ] NO

Deteriorating drums are visible along the northern protion of the site - limited clean-up activities are now in progress and the corroding drums are being re-containerized.

9. DIRECT VENTING OF STORAGE TANKS
[ ] YES [ ] NO No tanks

10. CONTAINERS HOLDING INCOMPATIBLE SUBSTANCES *(If "Yes", document evidence. Describe location and identity of hazardous waste. Take PHOTOGRAPHS.)*
[ ] YES [X] NO

11. INCOMPATIBLE SUBSTANCES STORED IN CLOSE PROXIMITY *(If "Yes", document evidence. Describe location and identity of hazardous waste. Take PHOTOGRAPHS.)*
[ ] YES [X] NO

12. ADEQUATE CONTAINER WASHING AND REUSE PRACTICES
[ ] YES [X] NO

13. ADEQUATE PRACTICES FOR DISPOSAL OF EMPTY STORAGE CONTAINERS
[X] YES [ ] NO

SURFACE IMPOUNDMENTS SITE INSPECTION REPORT
(Supplemental Report)

INSTRUCTION
Answer and Explain as Necessary.

1. TYPE OF IMPOUNDMENT

Earthen. See photo's 49 & 50

2. STABILITY/CONDITION OF EMBANKMENTS

Excellent

3. EVIDENCE OF SITE INSTABILITY *(Erosion, Settling, Sink Holes, etc.)*

[ ] YES [X] NO

4. EVIDENCE OF DISPOSAL OF IGNITABLE OR REACTIVE WASTE

[ ] YES [ ] NO No wastes

5. ONLY COMPATIBLE WASTES ARE STORED OR DISPOSED OF IN THE IMPOUNDMENT

[ ] YES [ ] NO No wastes

6. RECORDS CHECKED FOR CONTENTS AND LOCATION OF EACH SURFACE IMPOUNDMENT

[X] YES [ ] NO

7. IMPOUNDMENT HAS LINER SYSTEM

[ ] YES [X] NO

7a. INTEGRITY OF LINER SYSTEM CHECKED

[X] YES [ ] NO

7b. FINDINGS

No liner

8. SOIL STRUCTURE AND SUBSTRUCTURE

Clay soil with sandy clay substrate

9. MONITORING WELLS

[ ] YES [X] NO

10. LENGTH, WIDTH, AND DEPTH

LENGTH 800 ft.* WIDTH 100 ft.* DEPTH 12 ft.*

11. CALCULATED VOLUMETRIC CAPACITY

960,000 gallons*

12. PERCENT OF CAPACITY REMAINING

16%

13. ESTIMATE FREEBOARD

2 feet*

14. SOLIDS DEPOSITION

[ ] YES [X] NO

15. DREDGING DISPOSAL METHOD

None

16. OTHER EQUIPMENT

N/A

*Combined dimensions of two pits

EPA Form T2070-3C (10-79)

Site 11a - Sediment Retention Basin #1 (SRB-1) (#27)

SURFACE IMPOUNDMENTS SITE INSPECTION REPORT
(Supplemental Report)

INSTRUCTION
Answer and Explain as Necessary.

1. TYPE OF IMPOUNDMENT
Earthen. See photo's 51 & 52

2. STABILITY/CONDITION OF EMBANKMENTS
Excellent

3. EVIDENCE OF SITE INSTABILITY *(Erosion, Settling, Sink Holes, etc.)*
[ ] YES [X] NO

4. EVIDENCE OF DISPOSAL OF IGNITABLE OR REACTIVE WASTE
[ ] YES [X] NO

5. ONLY COMPATIBLE WASTES ARE STORED OR DISPOSED OF IN THE IMPOUNDMENT
[X] YES [ ] NO

6. RECORDS CHECKED FOR CONTENTS AND LOCATION OF EACH SURFACE IMPOUNDMENT
[X] YES [ ] NO

7. IMPOUNDMENT HAS LINER SYSTEM
[ ] YES [X] NO

7a. INTEGRITY OF LINER SYSTEM CHECKED
[X] YES [ ] NO

7b. FINDINGS
No liner

8. SOIL STRUCTURE AND SUBSTRUCTURE
Clay soil with sandy clay substrate

9. MONITORING WELLS
[X] YES [ ] NO Wells are in the area; however, none are site specific.

10. LENGTH, WIDTH, AND DEPTH
LENGTH 382 ft. WIDTH 46 ft. DEPTH 6 ft.

11. CALCULATED VOLUMETRIC CAPACITY
88,000 cubic feet

12. PERCENT OF CAPACITY REMAINING
16%

13. ESTIMATE FREEBOARD
1 foot

14. SOLIDS DEPOSITION
[X] YES [ ] NO

15. DREDGING DISPOSAL METHOD
Backhoe, front-end loader

16. OTHER EQUIPMENT
None

SURFACE IMPOUNDMENTS SITE INSPECTION REPORT
(Supplemental Report)

INSTRUCTION
Answer and Explain as Necessary.

1. TYPE OF IMPOUNDMENT
Earthen. See photo's 53 & 54

2. STABILITY/CONDITION OF EMBANKMENTS
Excellent

3. EVIDENCE OF SITE INSTABILITY *(Erosion, Settling, Sink Holes, etc.)*
[ ] YES [X] NO

4. EVIDENCE OF DISPOSAL OF IGNITABLE OR REACTIVE WASTE
[ ] YES [X] NO

5. ONLY COMPATIBLE WASTES ARE STORED OR DISPOSED OF IN THE IMPOUNDMENT
[X] YES [ ] NO

6. RECORDS CHECKED FOR CONTENTS AND LOCATION OF EACH SURFACE IMPOUNDMENT
[X] YES [ ] NO

7. IMPOUNDMENT HAS LINER SYSTEM
[ ] YES [X] NO

7a. INTEGRITY OF LINER SYSTEM CHECKED
[X] YES [ ] NO

7b. FINDINGS
No liner

8. SOIL STRUCTURE AND SUBSTRUCTURE
Clay soil with sandy clay substrate

9. MONITORING WELLS
[X] YES [ ] NO Wells are in the area; however, none are site specific

10. LENGTH, WIDTH, AND DEPTH
LENGTH 188 ft. WIDTH 190 ft. DEPTH 6 ft.

11. CALCULATED VOLUMETRIC CAPACITY
178,000 cubic feet

12. PERCENT OF CAPACITY REMAINING
16%

13. ESTIMATE FREEBOARD
1 foot

14. SOLIDS DEPOSITION
[X] YES [ ] NO

15. DREDGING DISPOSAL METHOD
Backhoe, front-end loader

16. OTHER EQUIPMENT
None

SURFACE IMPOUNDMENTS SITE INSPECTION REPORT
(Supplemental Report)

INSTRUCTION Answer and Explain as Necessary.

1. TYPE OF IMPOUNDMENT

Earthen. See photo's 55 & 56

2. STABILITY/CONDITION OF EMBANKMENTS

Excellent

3. EVIDENCE OF SITE INSTABILITY *(Erosion, Settling, Sink Holes, etc.)*

☐ YES ☒ NO

4. EVIDENCE OF DISPOSAL OF IGNITABLE OR REACTIVE WASTE

☐ YES ☒ NO

5. ONLY COMPATIBLE WASTES ARE STORED OR DISPOSED OF IN THE IMPOUNDMENT

☒ YES ☐ NO

6. RECORDS CHECKED FOR CONTENTS AND LOCATION OF EACH SURFACE IMPOUNDMENT

☒ YES ☐ NO

7. IMPOUNDMENT HAS LINER SYSTEM

☐ YES ☒ NO

7a. INTEGRITY OF LINER SYSTEM CHECKED

☒ YES ☐ NO

7b. FINDINGS

No liner

8. SOIL STRUCTURE AND SUBSTRUCTURE

Clay soil with sandy clay substrate

9. MONITORING WELLS

☒ YES ☐ NO Wells are in the area; however, none are site specific.

10. LENGTH, WIDTH, AND DEPTH

LENGTH 292 ft. WIDTH 104 ft. DEPTH 6 ft.

11. CALCULATED VOLUMETRIC CAPACITY

152,000 cubic feet

12. PERCENT OF CAPACITY REMAINING

16%

13. ESTIMATE FREEBOARD

1 foot

14. SOLIDS DEPOSITION

☒ YES ☐ NO

15. DREDGING DISPOSAL METHOD

Backhoe, front-end loader

16. OTHER EQUIPMENT

None

Site 11d, DDT Storage in Basement, Bldg. 54-2,

(#30)

STORAGE FACILITIES SITE INSPECTION REPORT (Supplemental Report)	INSTRUCTION Answer and Explain as Necessary.

1 STORAGE AREA HAS CONTINUOUS IMPERVIOUS BASE

[X] YES [ ] NO

2 STORAGE AREA HAS A CONFINEMENT STRUCTURE

[X] YES [ ] NO

3. EVIDENCE OF LEAKAGE/OVERFLOW *(If "Yes", document where and how much runoff is overflowing or leaking from containment)*

[ ] YES [X] NO

4. ESTIMATE TYPE AND NUMBER OF BARRELS/CONTAINERS

1 container (basement), concrete

5. GLASS OR PLASTIC STORAGE CONTAINERS USED

[ ] YES [X] NO

6. ESTIMATE NUMBER AND CAPACITY OF STORAGE TANKS

No tanks

7. NOTE LABELING ON CONTAINERS

N/A

8. EVIDENCE OF LEAKAGE CORROSION OR BULGING OF BARRELS/CONTAINERS/STORAGE TANKS *(If "Yes", document evidence. Describe location and extent of damage. Take PHOTOGRAPHS)*

[ ] YES [X] NO

9. DIRECT VENTING OF STORAGE TANKS

[ ] YES [ ] NO N/A

10. CONTAINERS HOLDING INCOMPATIBLE SUBSTANCES *(If "Yes", document evidence. Describe location and identity of hazardous waste. Take PHOTOGRAPHS.)*

[ ] YES [X] NO

11. INCOMPATIBLE SUBSTANCES STORED IN CLOSE PROXIMITY *(If "Yes", document evidence. Describe location and identity of hazardous waste. Take PHOTOGRAPHS.)*

[ ] YES [X] NO

12. ADEQUATE CONTAINER WASHING AND REUSE PRACTICES

[ ] YES [ ] NO N/A

13. ADEQUATE PRACTICES FOR DISPOSAL OF EMPTY STORAGE CONTAINERS

[ ] YES [ ] NO N/A

Site 11e - DOF Basement Storage, Bldg. 54 - 325 (#31)

STORAGE FACILITIES SITE INSPECTION REPORT (Supplemental Report)	INSTRUCTION Answer and Explain as Necessary.

1. STORAGE AREA HAS CONTINUOUS IMPERVIOUS BASE
[X] YES [ ] NO

2. STORAGE AREA HAS A CONFINEMENT STRUCTURE
[X] YES [ ] NO

3. EVIDENCE OF LEAKAGE/OVERFLOW *(If "Yes", document where and how much runoff is overflowing or leaking from containment)*
[ ] YES [X] NO

4. ESTIMATE TYPE AND NUMBER OF BARRELS/CONTAINERS
1 concrete container (basement)

5. GLASS OR PLASTIC STORAGE CONTAINERS USED
[ ] YES [X] NO

6. ESTIMATE NUMBER AND CAPACITY OF STORAGE TANKS
No tanks

7. NOTE LABELING ON CONTAINERS
N/A

8. EVIDENCE OF LEAKAGE CORROSION OR BULGING OF BARRELS/CONTAINERS/STORAGE TANKS *(If "Yes", document evidence. Describe location and extent of damage. Take PHOTOGRAPHS)*
[ ] YES [X] NO

9. DIRECT VENTING OF STORAGE TANKS
[ ] YES [ ] NO N/A

10. CONTAINERS HOLDING INCOMPATIBLE SUBSTANCES *(If "Yes", document evidence. Describe location and identity of hazardous waste. Take PHOTOGRAPHS.)*
[ ] YES [X] NO

11. INCOMPATIBLE SUBSTANCES STORED IN CLOSE PROXIMITY *(If "Yes", document evidence. Describe location and identity of hazardous waste. Take PHOTOGRAPHS.)*
[ ] YES [X] NO

12. ADEQUATE CONTAINER WASHING AND REUSE PRACTICES
[ ] YES [ ] NO N/A

13. ADEQUATE PRACTICES FOR DISPOSAL OF EMPTY STORAGE CONTAINERS
[ ] YES [ ] NO N/A

EPA Form T2070-3D (10-79)

Site 11f-DDT .te Stockfile/Landfill (#32)

LANDFILLS SITE INSPECTION REPORT (Supplemental Report)	INSTRUCTION Answer and Explain as Necessary.

1. EVIDENCE OF SITE INSTABILITY *(Erosion, Settling, Sink Holes, etc)*
☐ YES ☒ NO

2. EVIDENCE OF IMPROPER DISPOSAL OF BULK LIQUIDS, SEMI-SOLIDS AND SLUDGES INTO THE LANDFILL
☐ YES ☒ NO

3. CHECK RECORDS OF CELL LOCATION AND CONTENTS AND BENCHMARK
☒ YES ☐ NO

4. WASTES SURROUNDED BY SORBENT MATERIAL
☒ YES ☐ NO

5. DIVERSION STRUCTURES ARE EFFECTIVELY CONSTRUCTED AND PROPERLY MAINTAINED
☐ YES ☒ NO No diversion structures

6. EVIDENCE OF PONDING OF WATER ON SITE
☐ YES ☒ NO

7. EVIDENCE OF IMPROPER/INADEQUATE DRAINING
☐ YES ☒ NO

8. ADEQUATE LEACHATE COLLECTION SYSTEM *(If "Yes", specify Type)*
☐ YES ☒ NO

8a. SURFACE LEACHATE SPRING
☐ YES ☒ NO

9. RECORDS OF LEACHATE ANALYSIS
☐ YES ☒ NO

10. GAS MONITORING
☐ YES ☒ NO

11. GROUNDWATER MONITORING WELLS
☒ YES ☐ NO Wells are in the area; however, none are site specific

12. ARTIFICIAL MEMBRANE LINER INSTALLED
☐ YES ☒ NO

13. SPECIFIC CONTAINMENT MEASURES *(Clay Bottom, Sides, etc)*
☐ YES ☒ NO

14. FIXATION *(Stabilization)* OF WASTE
☐ YES ☒ NO

15. ADEQUATE CLOSURE OF INACTIVE PORTION OF FACILITY
☒ YES ☐ NO

16. COVER *(Type)*
Clay

16a. THICKNESS
2 feet

16b. PERMEABILITY
Low

16c. DAILY APPLICATION
☐ YES ☒ NO

LANDFILLS SITE INSPECTION REPORT
(Supplemental Report)

INSTRUCTION
Answer and Explain as Necessary.

1. EVIDENCE OF SITE INSTABILITY *(Erosion, Settling, Sink Holes, etc)*
☐ YES ☒ NO

2. EVIDENCE OF IMPROPER DISPOSAL OF BULK LIQUIDS, SEMI-SOLIDS AND SLUDGES INTO THE LANDFILL
☐ YES ☒ NO

3. CHECK RECORDS OF CELL LOCATION AND CONTENTS AND BENCHMARK
☒ YES ☐ NO

4. WASTES SURROUNDED BY SORBENT MATERIAL
☒ YES ☐ NO

5. DIVERSION STRUCTURES ARE EFFECTIVELY CONSTRUCTED AND PROPERLY MAINTAINED
☒ YES ☐ NO

6. EVIDENCE OF PONDING OF WATER ON SITE
☐ YES ☒ NO

7. EVIDENCE OF IMPROPER/INADEQUATE DRAINING
☐ YES ☒ NO

8. ADEQUATE LEACHATE COLLECTION SYSTEM *(If "Yes", specify Type)*
☐ YES ☒ NO

8a. SURFACE LEACHATE SPRING
☐ YES ☒ NO

9. RECORDS OF LEACHATE ANALYSIS
☐ YES ☒ NO

10. GAS MONITORING
☐ YES ☒ NO

11. GROUNDWATER MONITORING WELLS
☒ YES ☐ NO Wells are in the area, however, none are site specific.

12. ARTIFICIAL MEMBRANE LINER INSTALLED
☐ YES ☒ NO

13. SPECIFIC CONTAINMENT MEASURES *(Clay Bottom, Sides, etc)*
☐ YES ☒ NO

14. FIXATION *(Stabilization)* OF WASTE
☐ YES ☒ NO

15. ADEQUATE CLOSURE OF INACTIVE PORTION OF FACILITY
☒ YES ☐ NO

16. COVER *(Type)*
Clay

16a. THICKNESS
2 feet

16b. PERMEABILITY
Low

16c. DAILY APPLICATION
☐ YES ☒ NO

Site 27 - nt BZ Pond (#35)

SURFACE IMPOUNDMENTS SITE INSPECTION REPORT *(Supplemental Report)*	INSTRUCTION Answer and Explain as Necessary.

1. TYPE OF IMPOUNDMENT

Agent BZ retention pond. See photo 62

2. STABILITY/CONDITION OF EMBANKMENTS

Stable

3. EVIDENCE OF SITE INSTABILITY *(Erosion, Settling, Sink Holes, etc.)*

[ ] YES [X] NO

4. EVIDENCE OF DISPOSAL OF IGNITABLE OR REACTIVE WASTE

[X] YES [ ] NO Thermite was disposed here

5 ONLY COMPATIBLE WASTES ARE STORED OR DISPOSED OF IN THE IMPOUNDMENT

[X] YES [ ] NO

6. RECORDS CHECKED FOR CONTENTS AND LOCATION OF EACH SURFACE IMPOUNDMENT

[X] YES [ ] NO

7. IMPOUNDMENT HAS LINER SYSTEM

[ ] YES [X] NO

7a. INTEGRITY OF LINER SYSTEM CHECKED

[X] YES [ ] NO

7b. FINDINGS

No liner

8. SOIL STRUCTURE AND SUBSTRUCTURE

Pleistocene terrace deposits; sandy substrate.

9. MONITORING WELLS

[X] YES [ ] NO 90' ENE of pond

10. LENGTH, WIDTH, AND DEPTH

LENGTH 160 ft. WIDTH 60 ft. DEPTH 12 to 15'

11. CALCULATED VOLUMETRIC CAPACITY

120,000 to 140,000 cubic feet

12. PERCENT OF CAPACITY REMAINING

Less than 5%

13. ESTIMATE FREEBOARD

24 to 36 inches

14. SOLIDS DEPOSITION

[X] YES [ ] NO

15. DREDGING DISPOSAL METHOD

Dredged material spread on banks & ground east of pond, also at site 24 (Thermite waste site).

16. OTHER EQUIPMENT

EPA Form T2070-3C (10-79)

Si 23 - White Smoke Test Pond (#36)

SURFACE IMPOUNDMENTS SITE INSPECTION REPORT
(Supplemental Report)

INSTRUCTION
Answer and Explain as Necessary.

1. TYPE OF IMPOUNDMENT
White smoke test pond (earthen)

2. STABILITY/CONDITION OF EMBANKMENTS
There are no dikes around pond. The natural contours of the land result in a shallow slope to the waste edge. The pond drains to the southeast.

3. EVIDENCE OF SITE INSTABILITY *(Erosion, Settling, Sink Holes, etc.)*
[ ] YES [X] NO

4. EVIDENCE OF DISPOSAL OF IGNITABLE OR REACTIVE WASTE
[X] YES [ ] NO Pond was used to test smoke pots and smoke grenades.

5. ONLY COMPATIBLE WASTES ARE STORED OR DISPOSED OF IN THE IMPOUNDMENT
[X] YES [ ] NO

6. RECORDS CHECKED FOR CONTENTS AND LOCATION OF EACH SURFACE IMPOUNDMENT
[X] YES [ ] NO

7. IMPOUNDMENT HAS LINER SYSTEM
[ ] YES [X] NO

7a. INTEGRITY OF LINER SYSTEM CHECKED
[ ] YES [ ] NO N/A

7b. FINDINGS
N/A

8. SOIL STRUCTURE AND SUBSTRUCTURE
Pleistocene terrace deposits, sandy clay substrate.

9. MONITORING WELLS
[X] YES [ ] NO Not specifically related to pond

10. LENGTH, WIDTH, AND DEPTH
LENGTH 400 ft. WIDTH 300 ft. DEPTH 5 ft.

11. CALCULATED VOLUMETRIC CAPACITY
14 acre feet

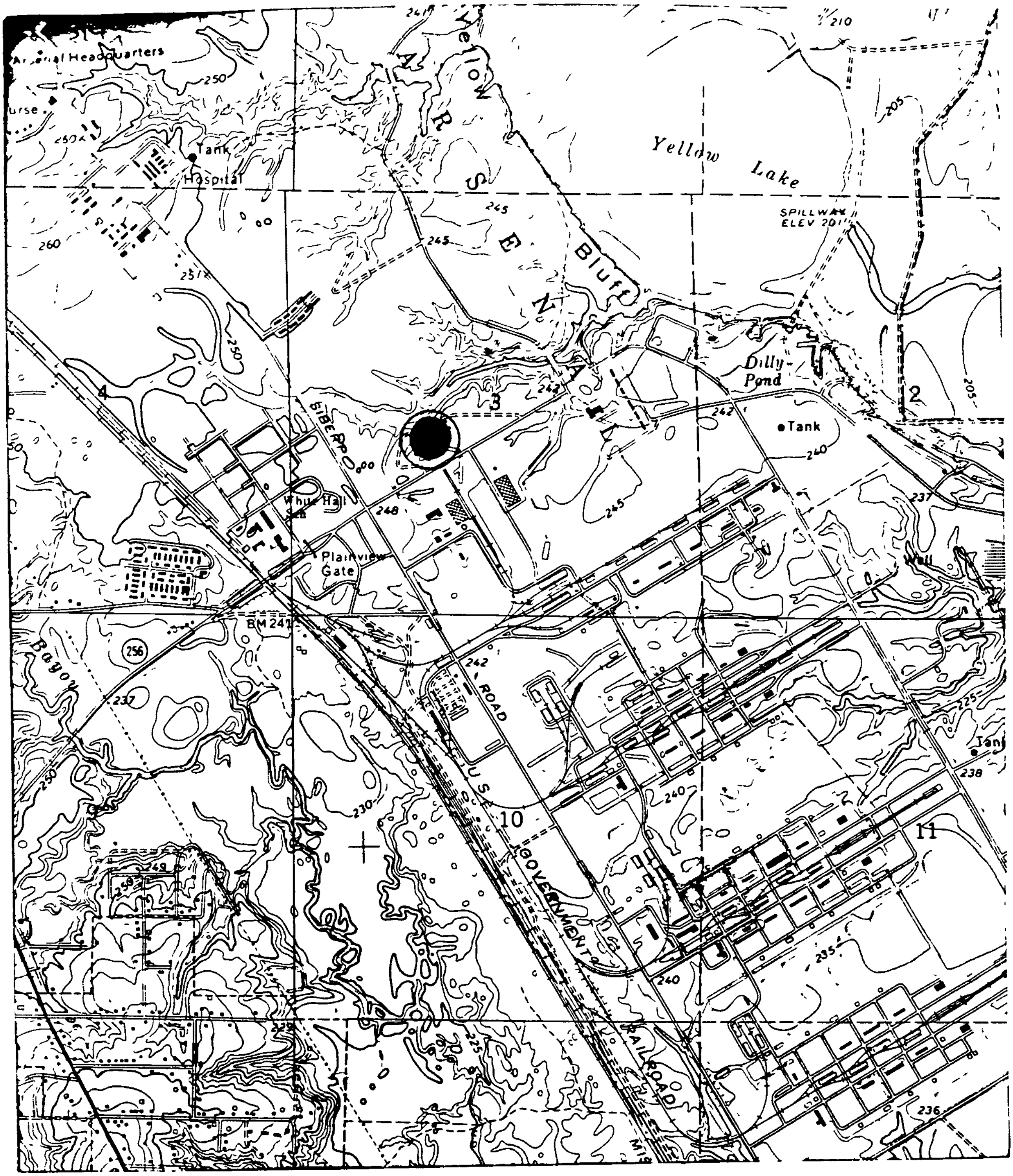
12. PERCENT OF CAPACITY REMAINING
Pond was draining during inspection, therefore it is at capacity.

13. ESTIMATE FREEBOARD
The freeboard varies considerably around pond. As it is draining to SE, freeboard may be considered zero.

14. SOLIDS DEPOSITION
[X] YES [ ] NO Bottom is littered with smoke grenades and smoke pots.

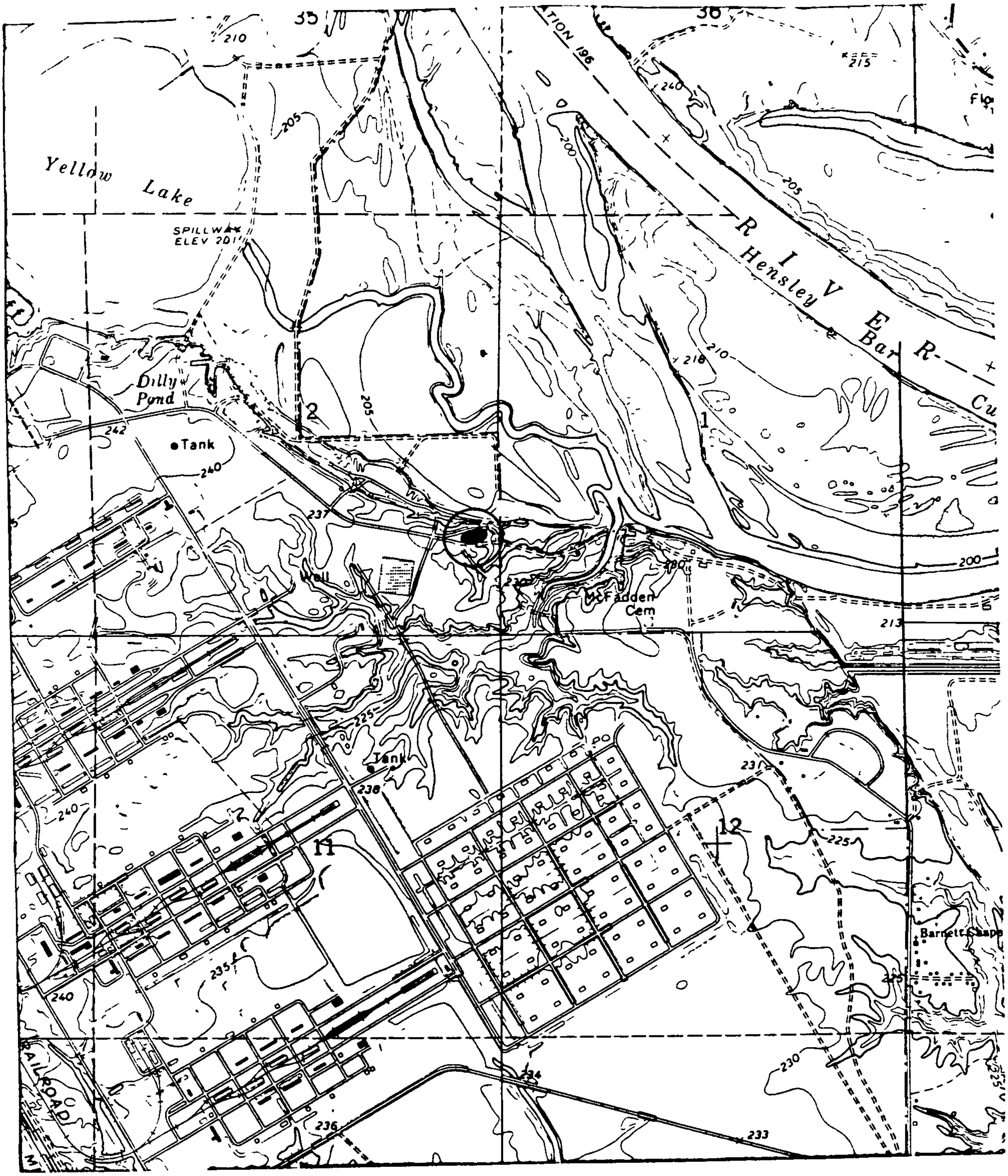
15. DREDGING DISPOSAL METHOD
None

16. OTHER EQUIPMENT
None



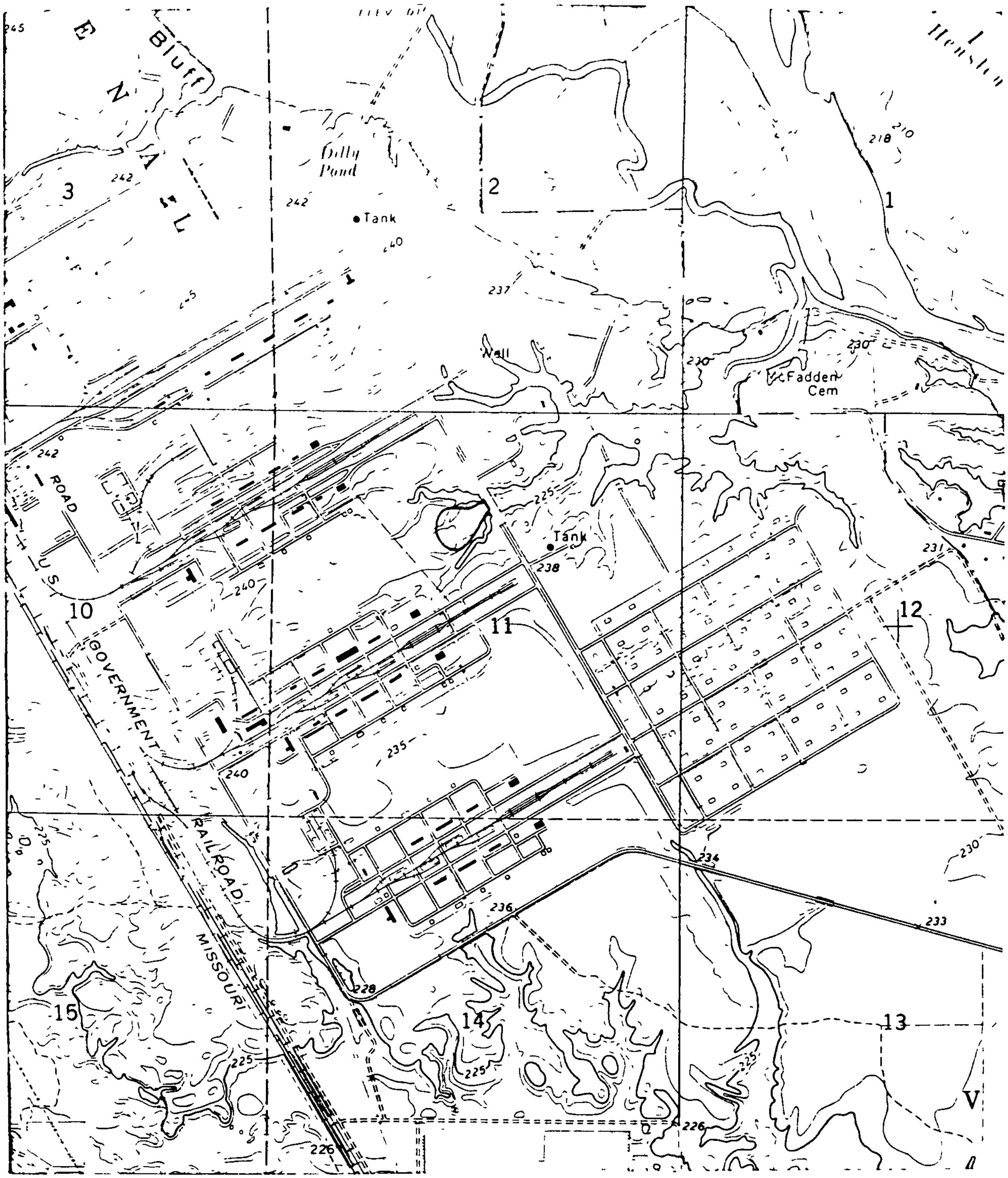
Site 16 a White Phosphorus Settling Pond

Scale: 1 inch = 2000 feet USGS map White Hall, Ark.



Site 20 b White Phosphorus Slag Burn Pit

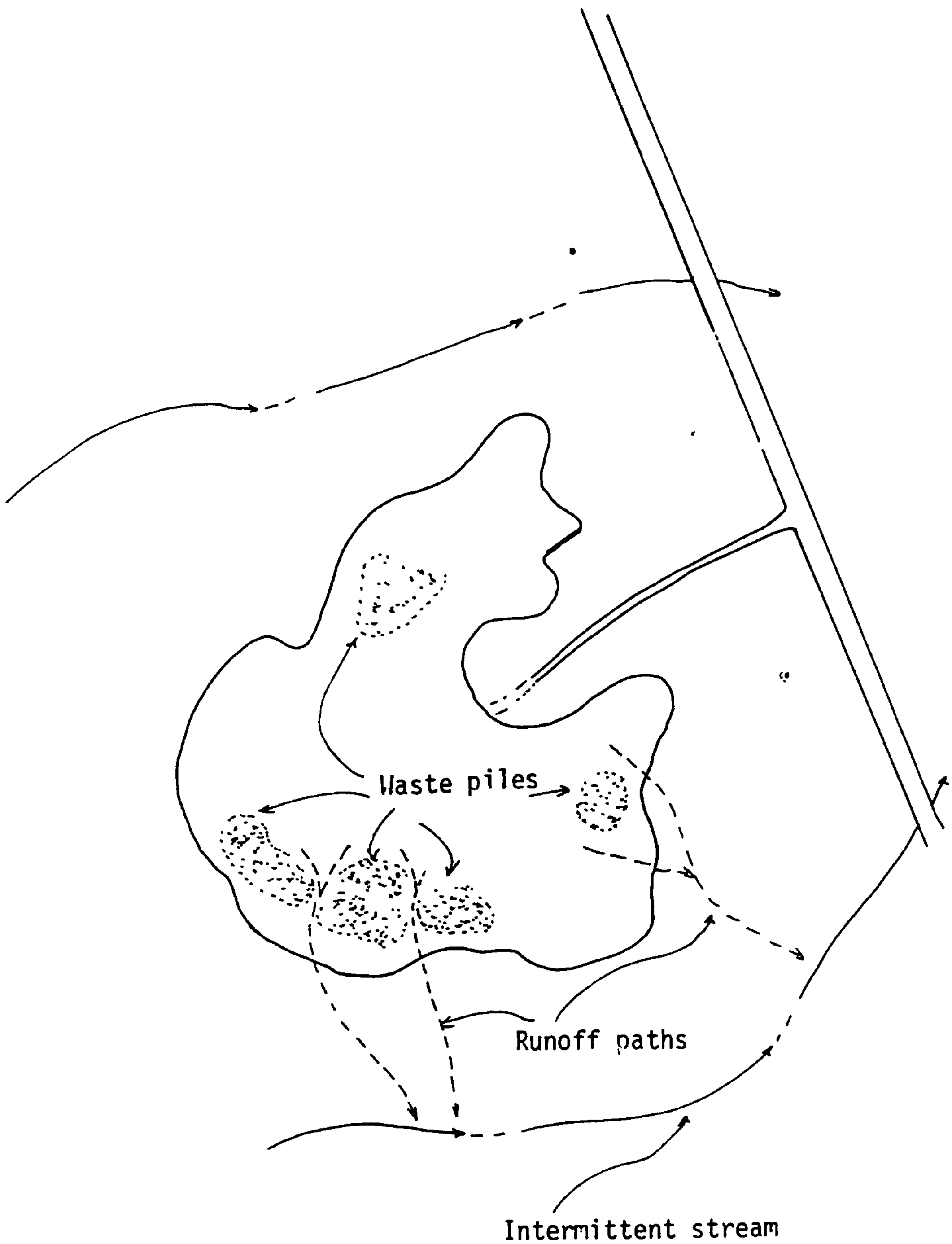
Scale: 1 inch = 2000 feet USGS map White Hall, Ark.



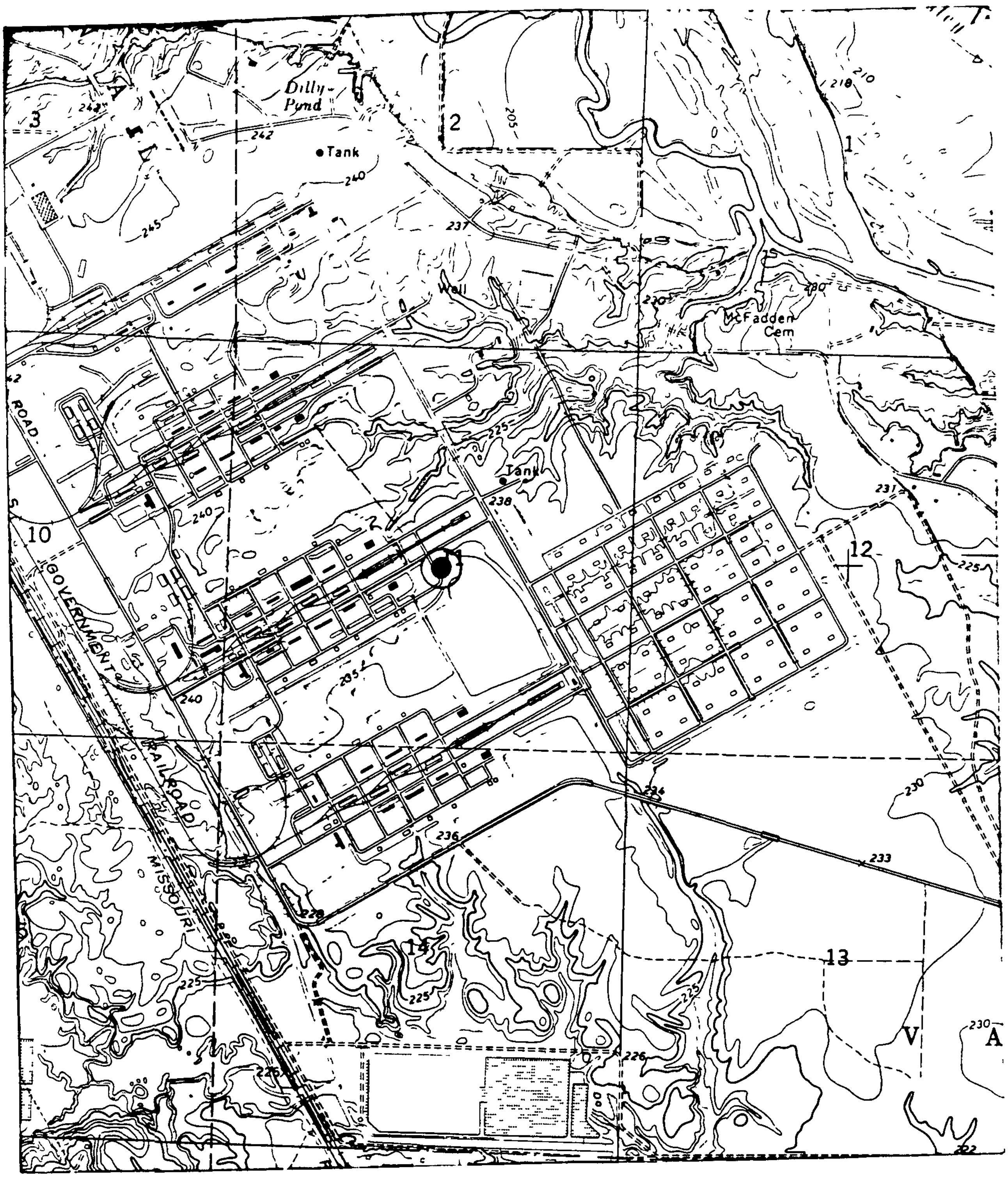
Site 24 Thermite Waste Disposal

Scale: 1 inch = 2000 feet

USGS map White Hall, Ark.

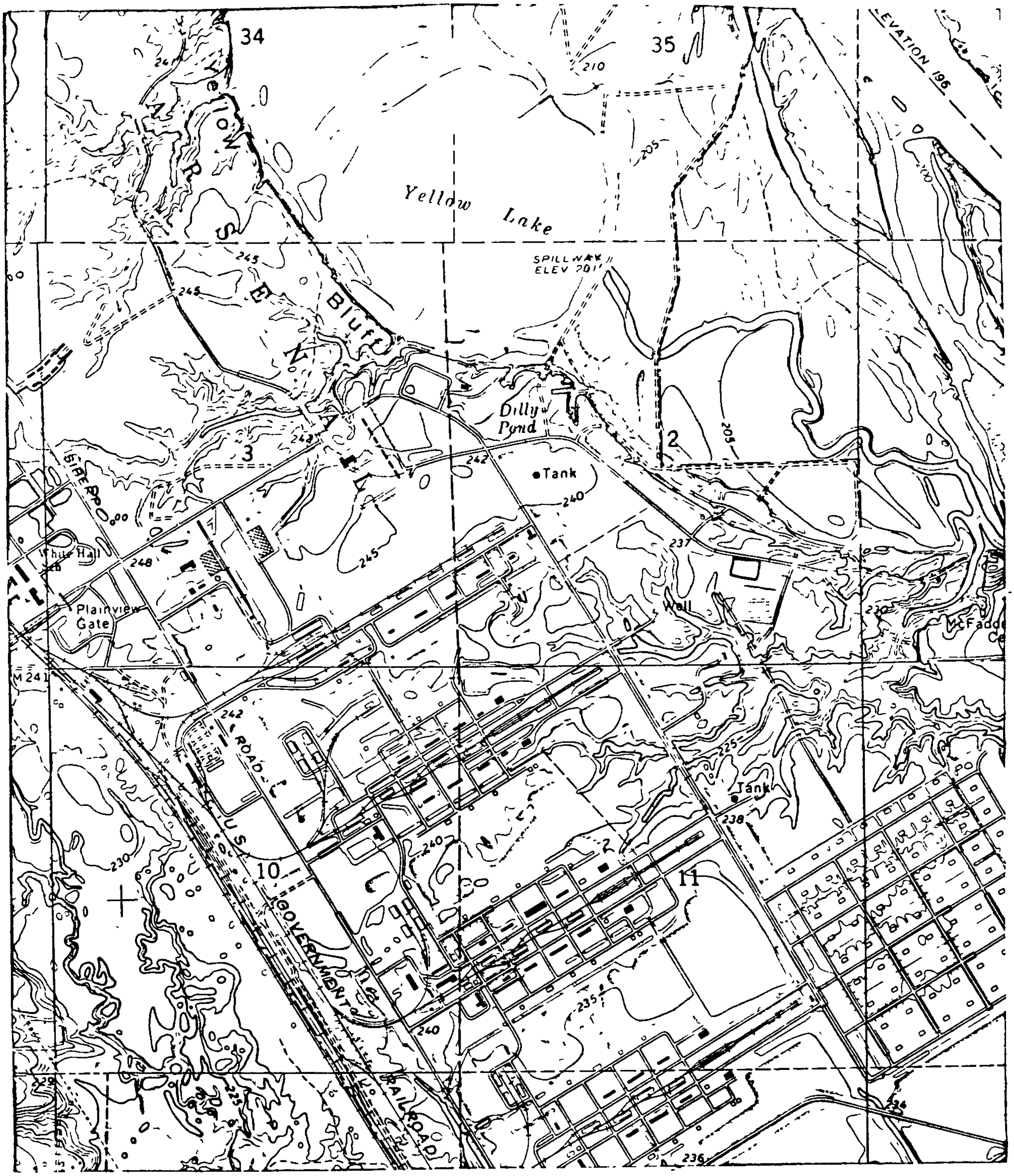


Site 24 Thermite Waste Disposal Site



Site 26 Quality Assurance Drop Test Tower

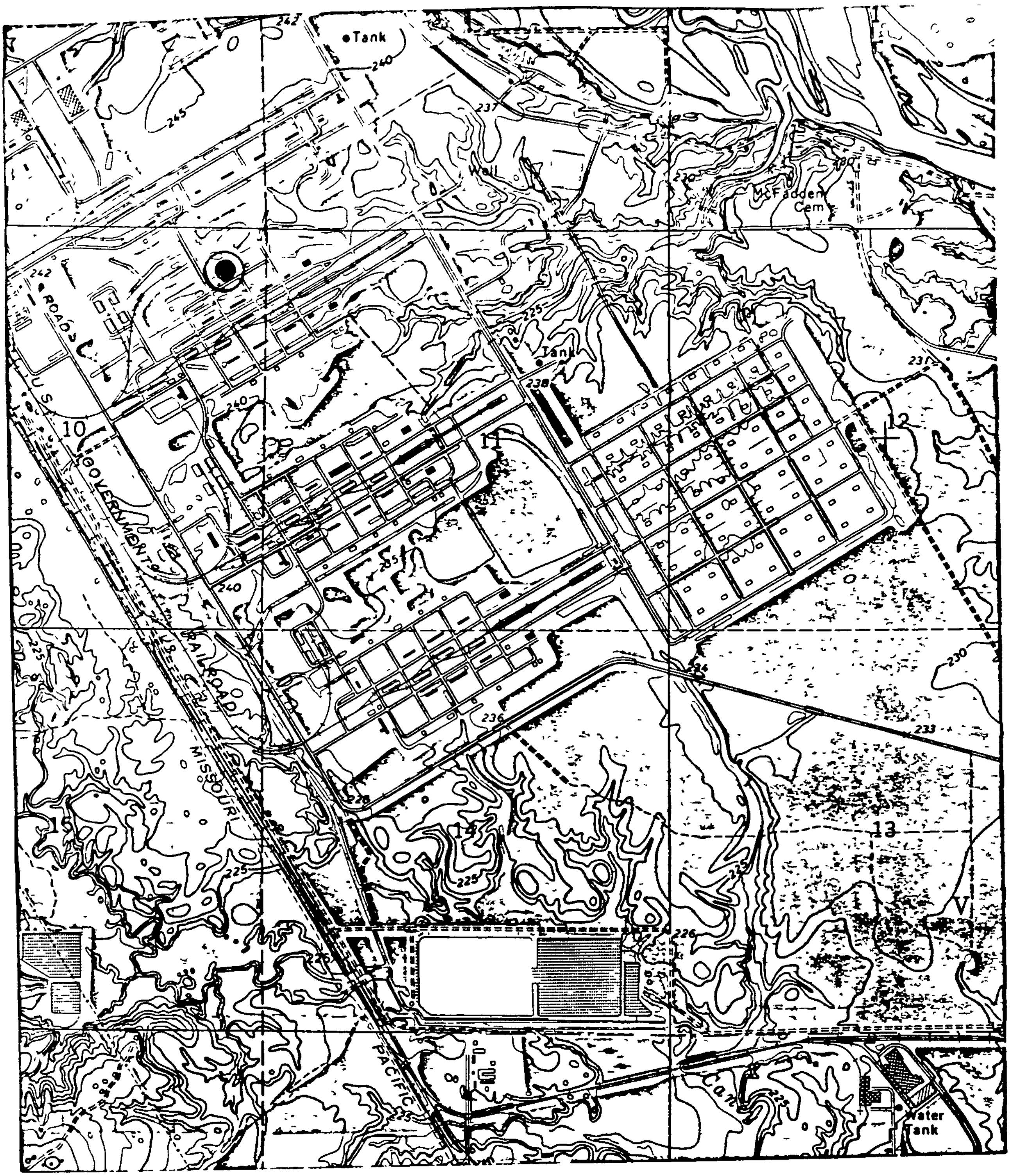
Scale: 1 inch = 2000 feet USGS map White Hall, Ark.



Site 40 Incinerator Complex

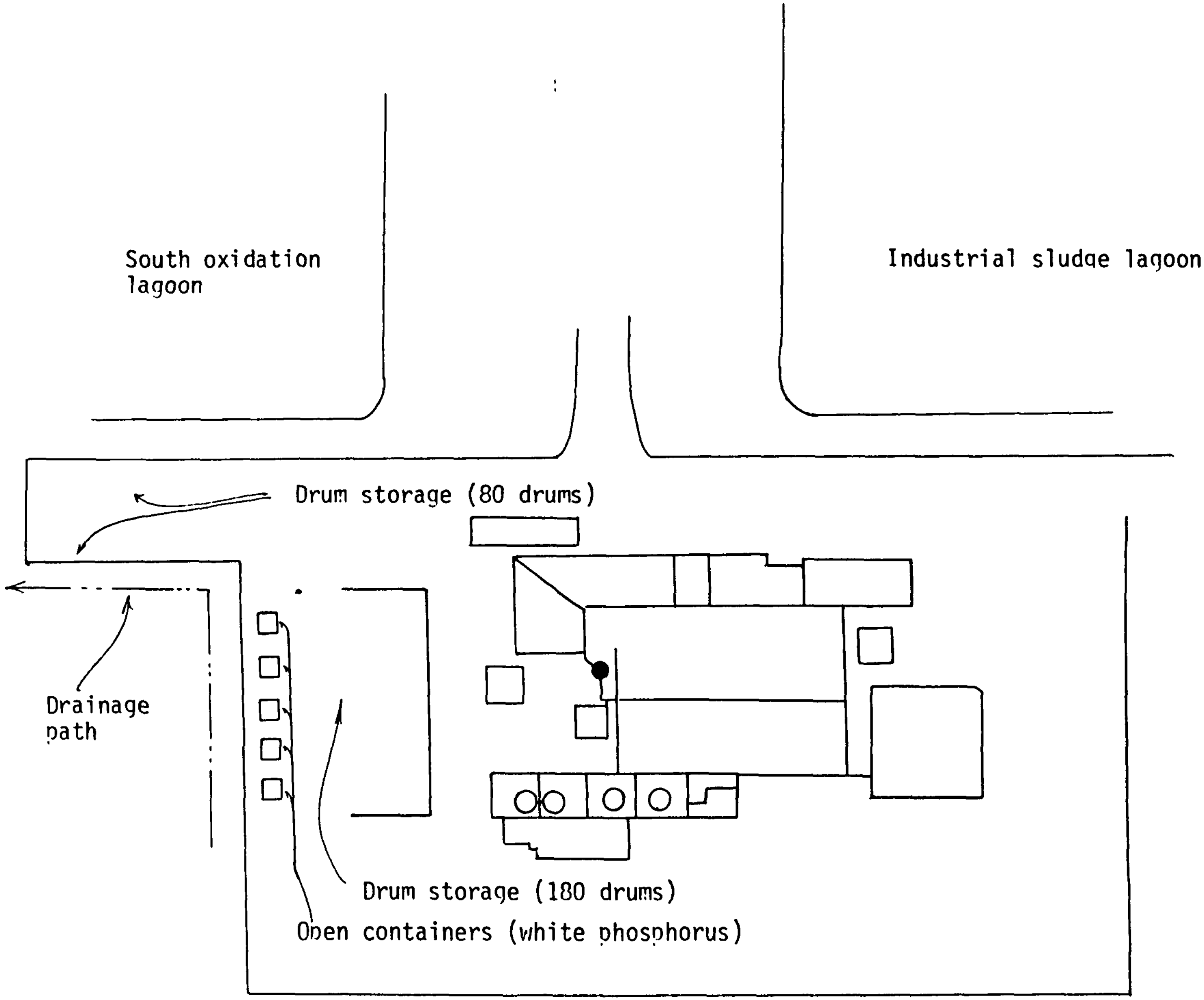
Scale: 1 inch = 2000 feet

USGS map White Hall, Ark.

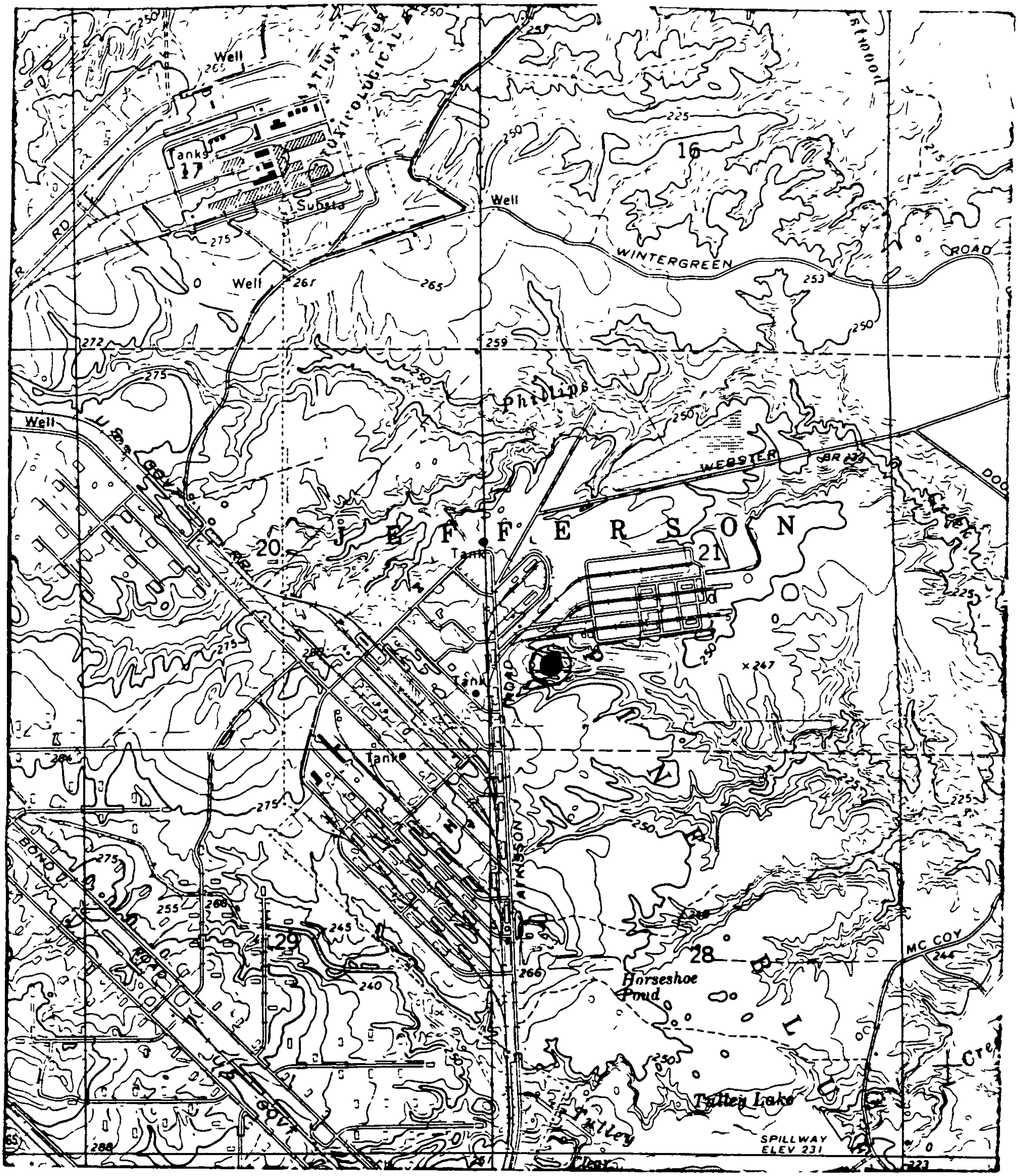


Site 31a Goat Shed Test Site

USGS

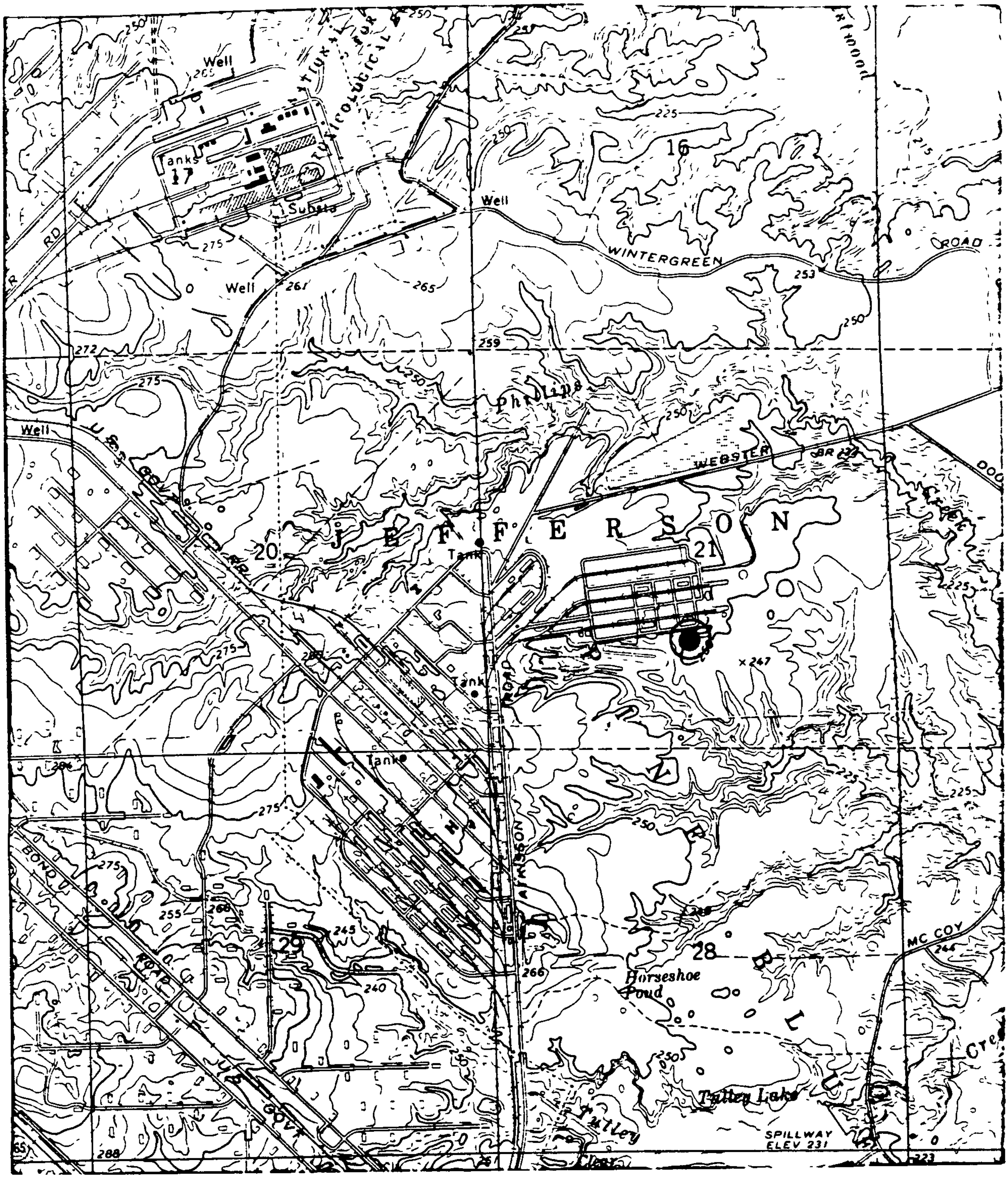


SITE 40 INCINERATOR COMPLEX



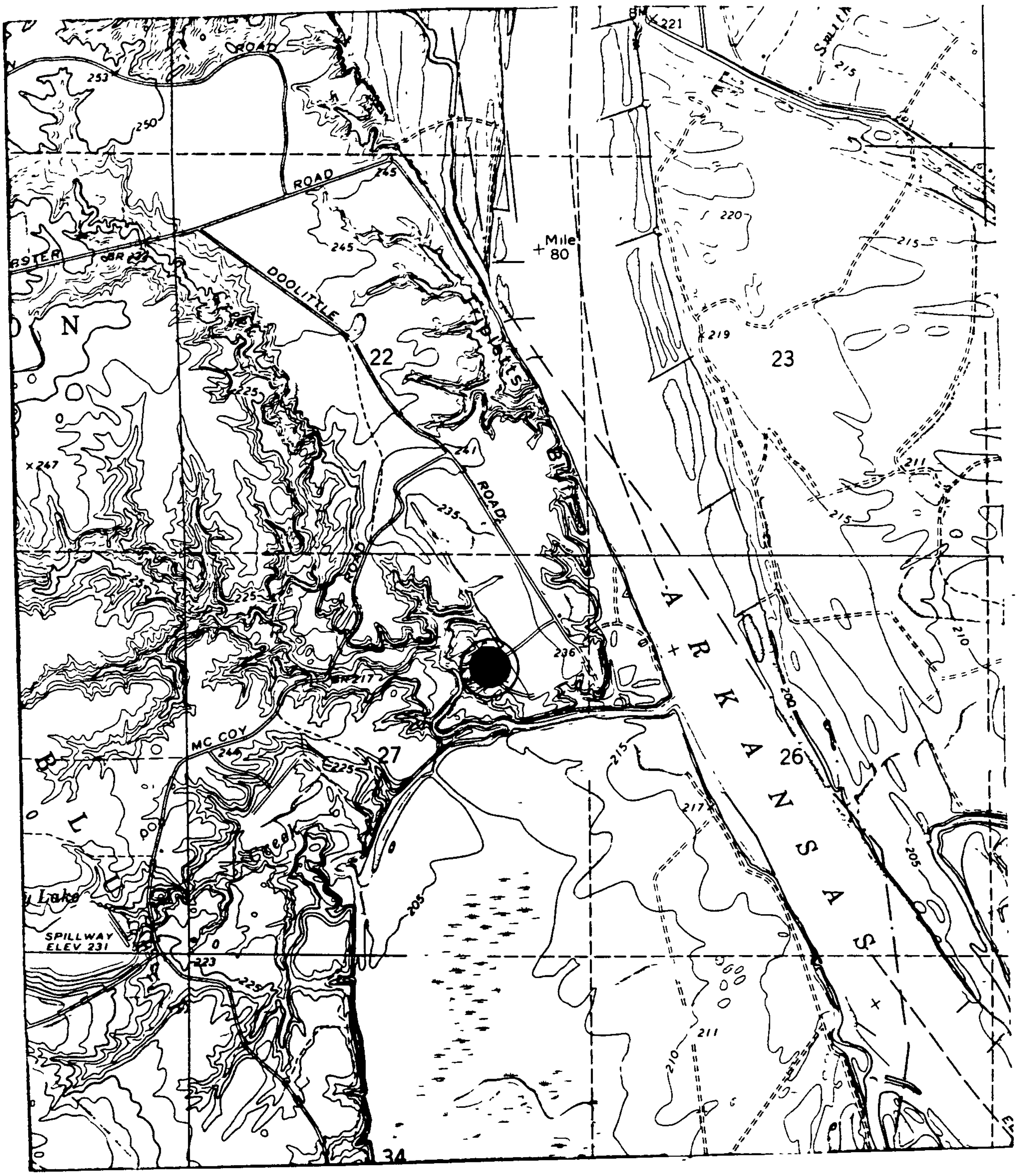
Site 7b Lewisite Disposal Site

USGS



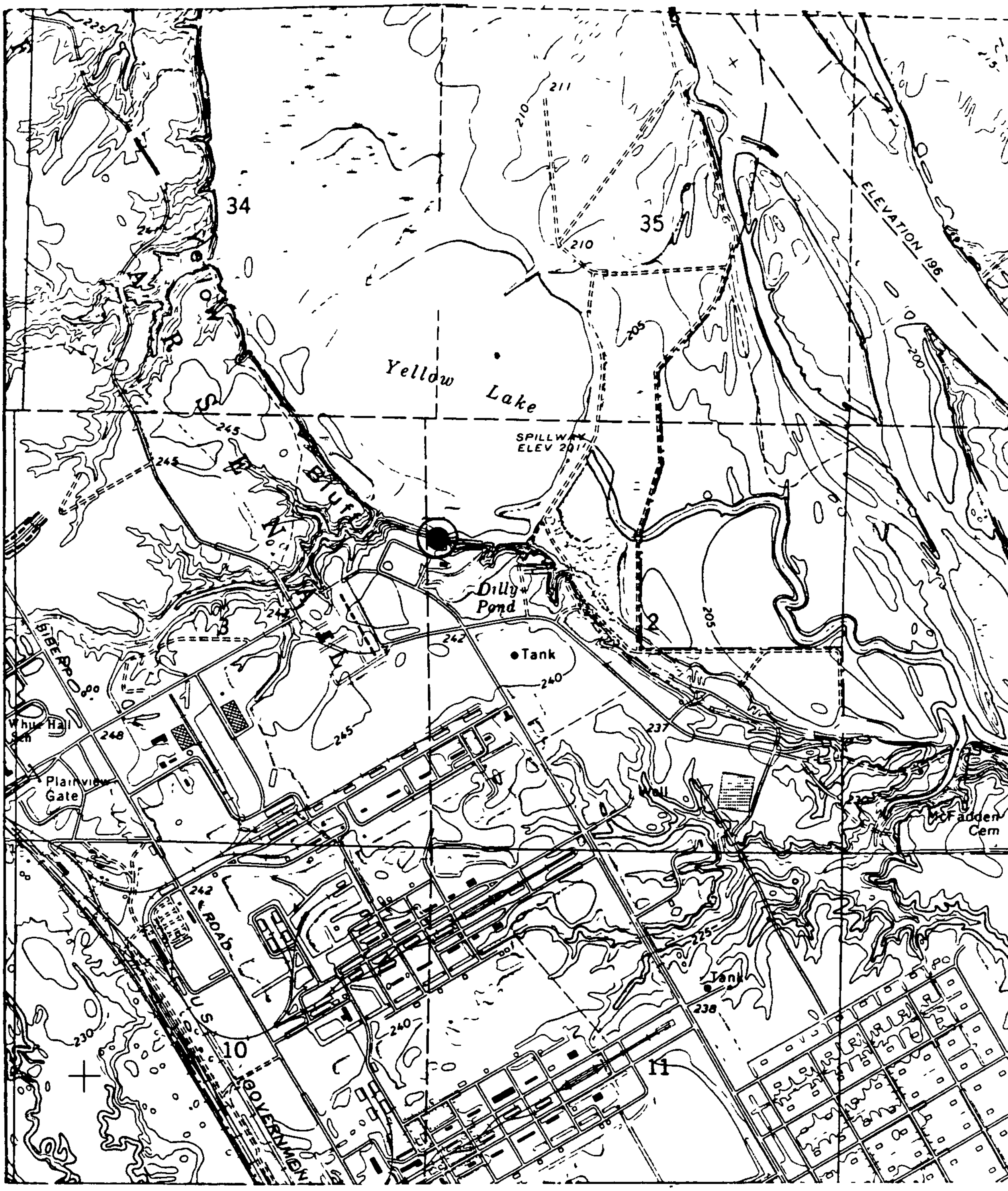
Site 7c Mustard Burn Yard

USGS



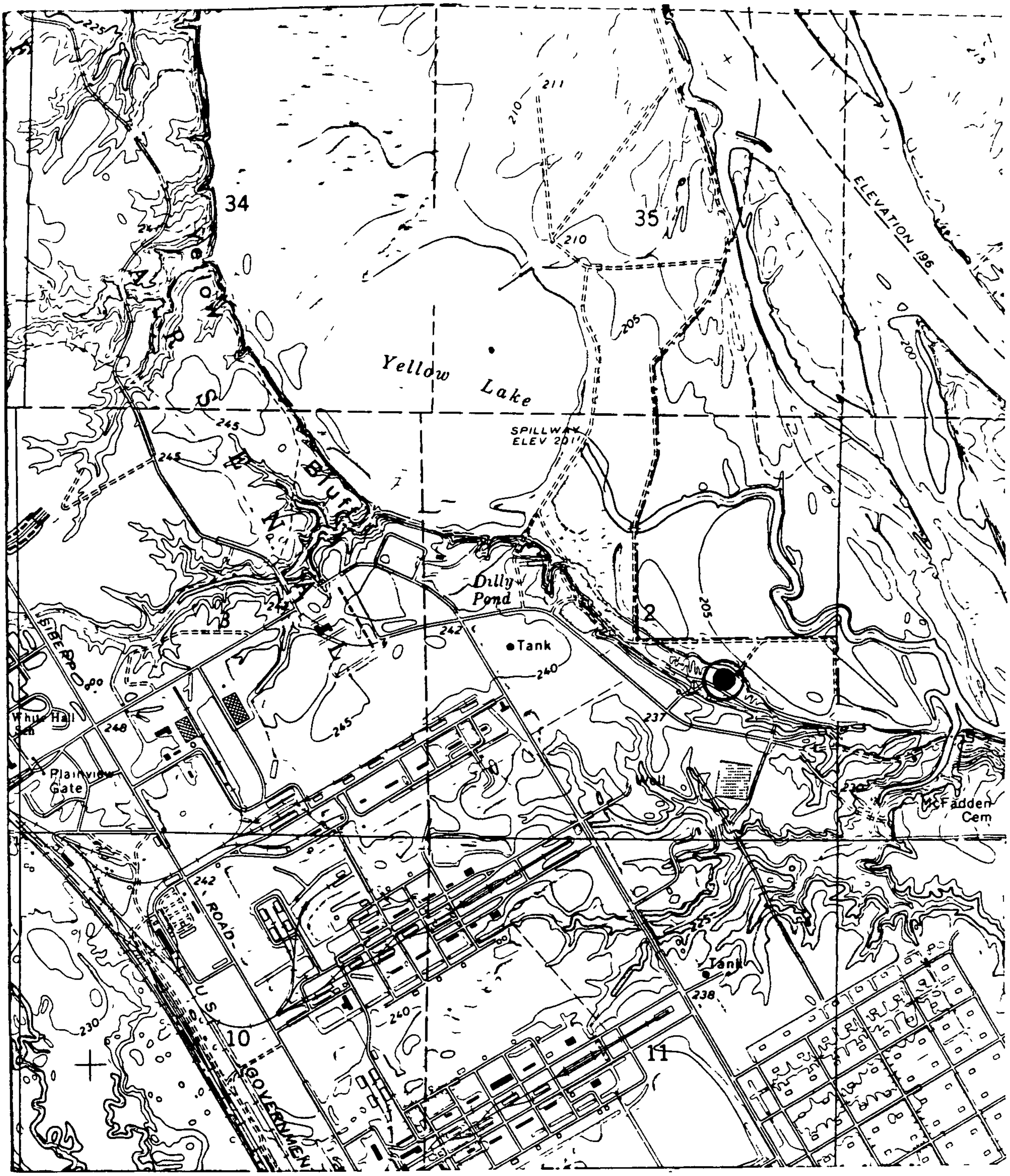
Site 10 Depot Burning and Demolition Area

USGS



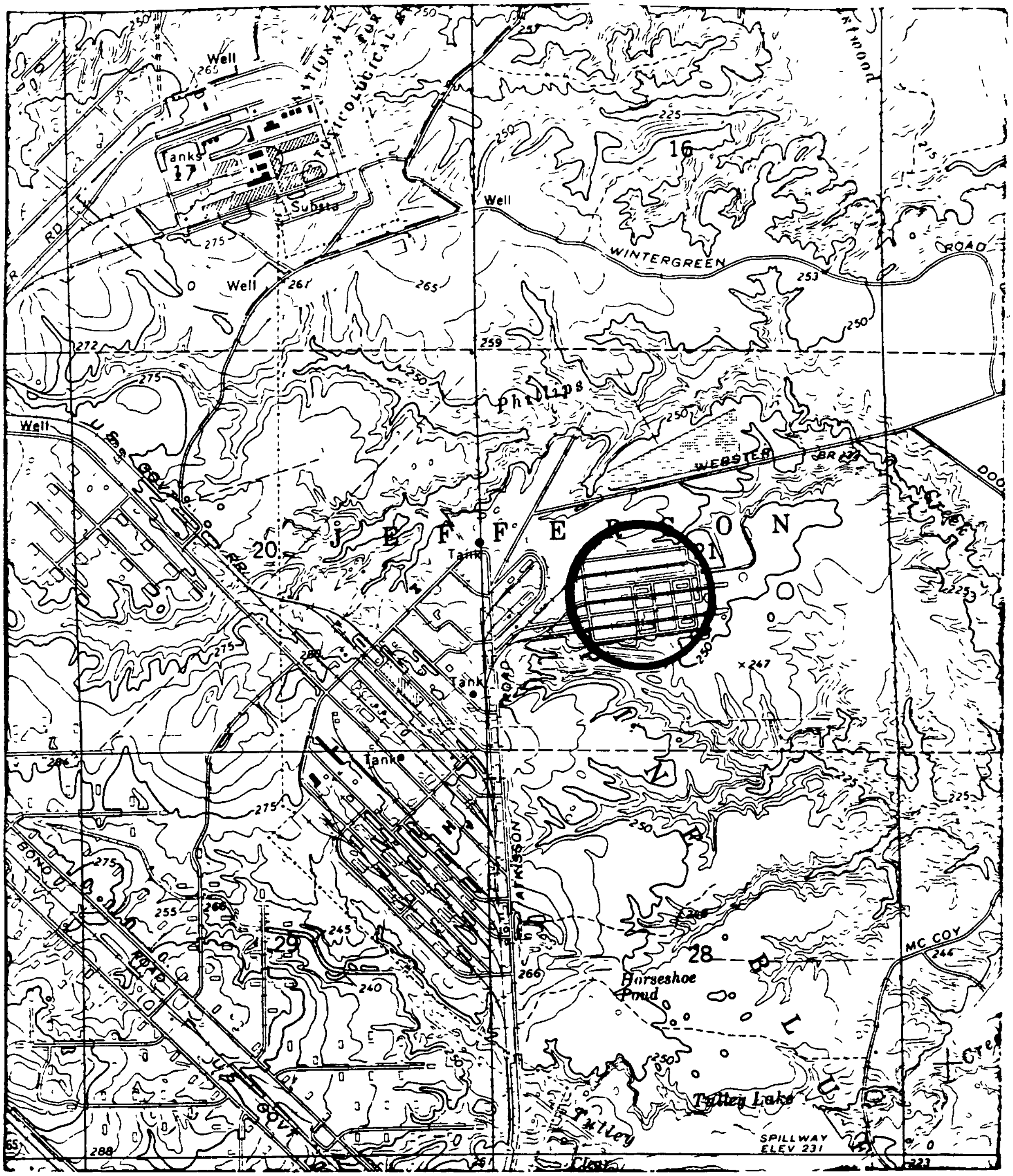
Site 17 Product Assurance Test Range and Dump Site

USGS



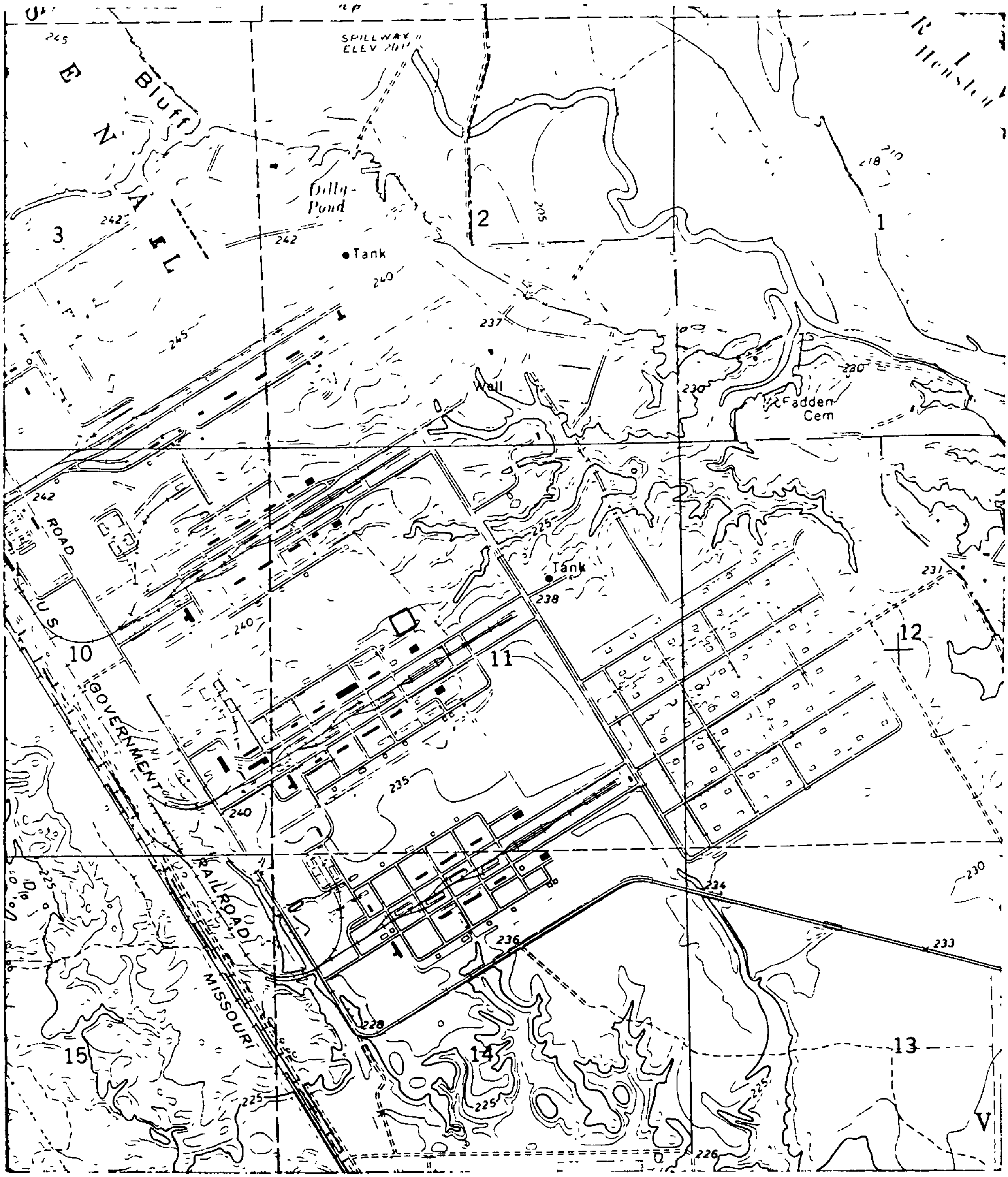
Site 20a Depot South Burn Pit and Storage Area

USGS



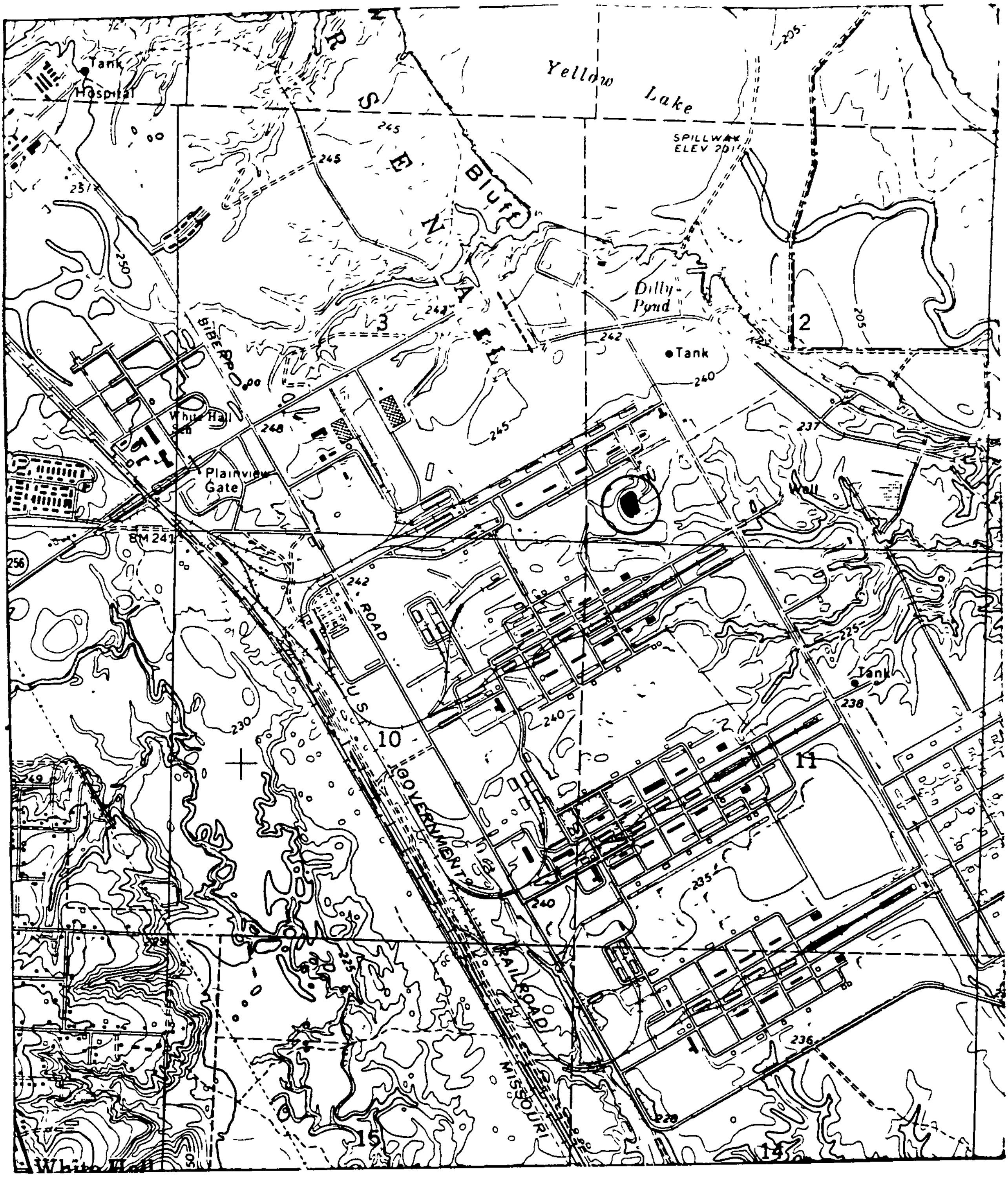
Site 7a Toxic Storage Yard

USGS



Site 27 Agent BZ Pond

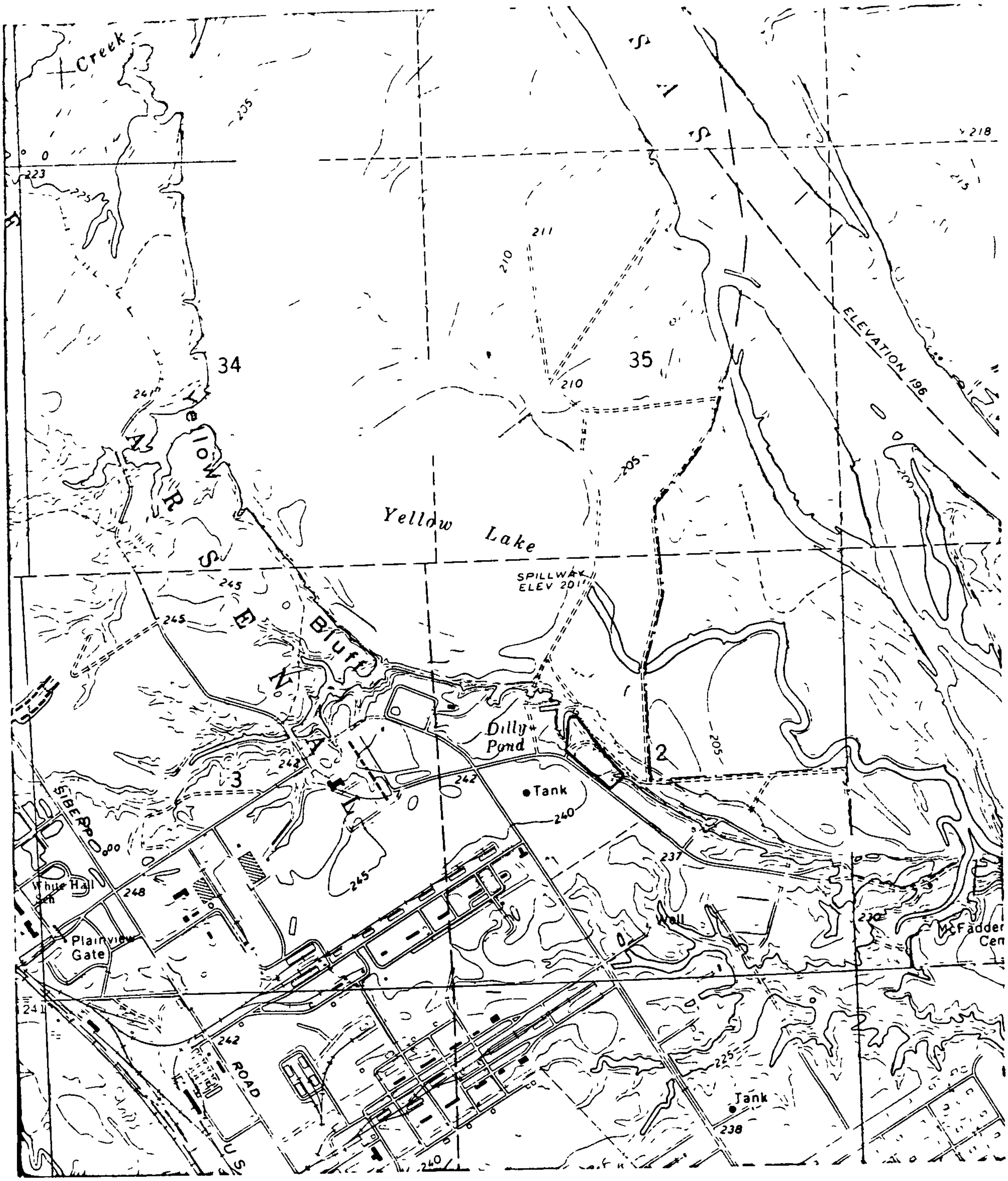
Scale: 1 inch = 2000 feet USGS map White Hall, Ark.



Site 23 a White Smoke Test Pond

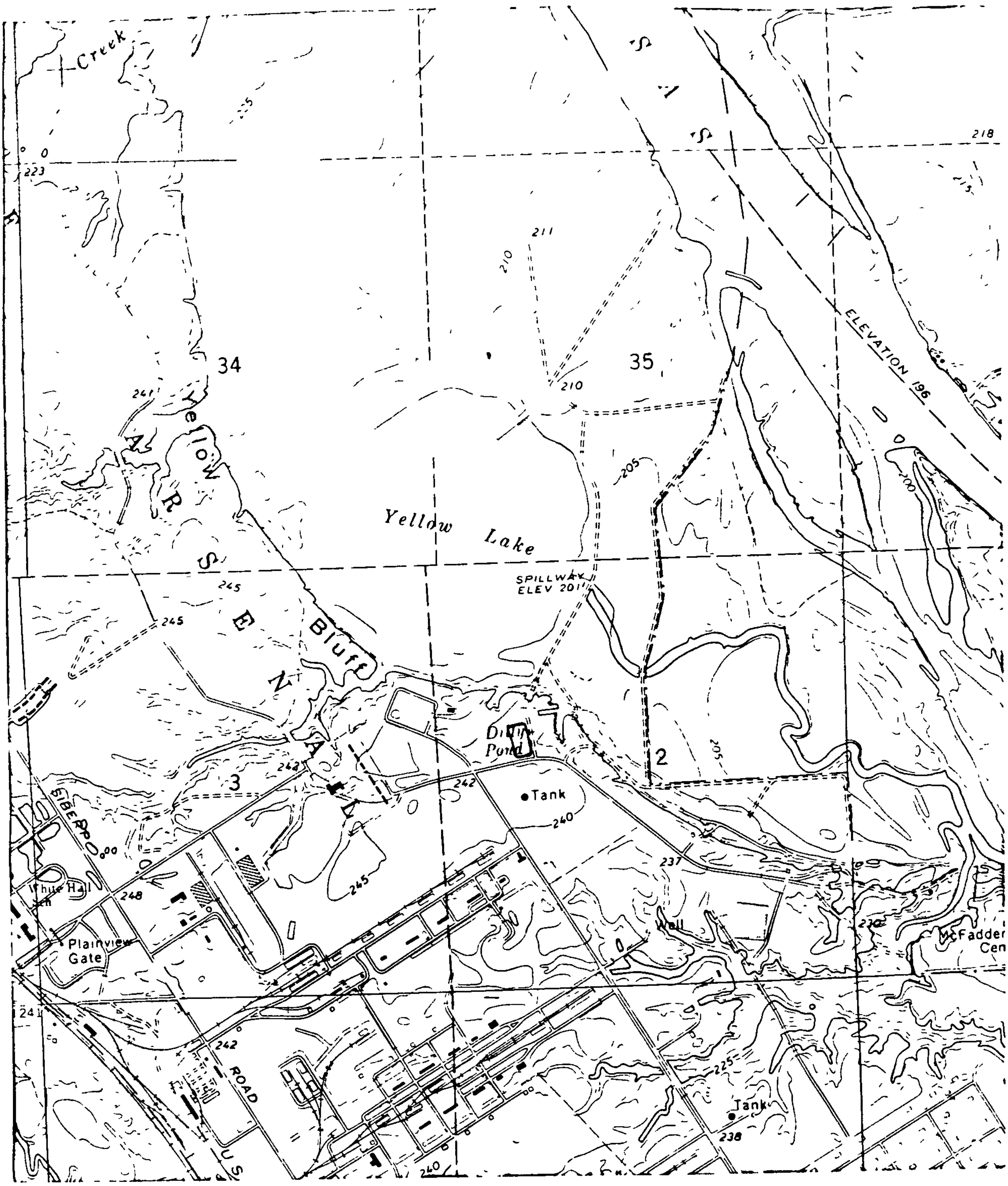
Scale: 1 inch = 2000 feet

USGS map White Hall, Ark.



Site 18-a Current Sanitary Landfill

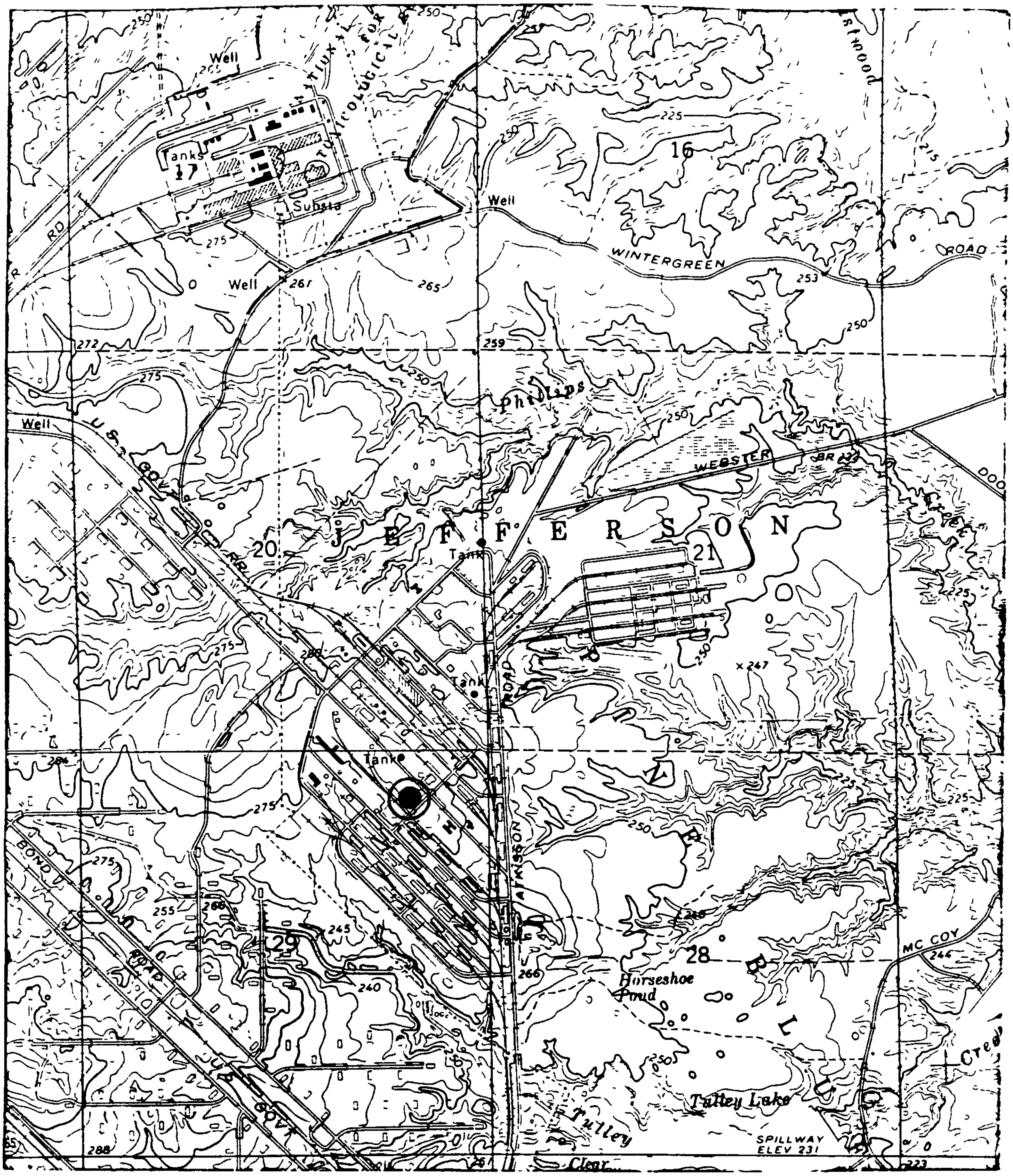
Scale: 1 inch = 2000 feet   USGS map White Hall, Ark.



Site 18-b Facilities Rubble Pile

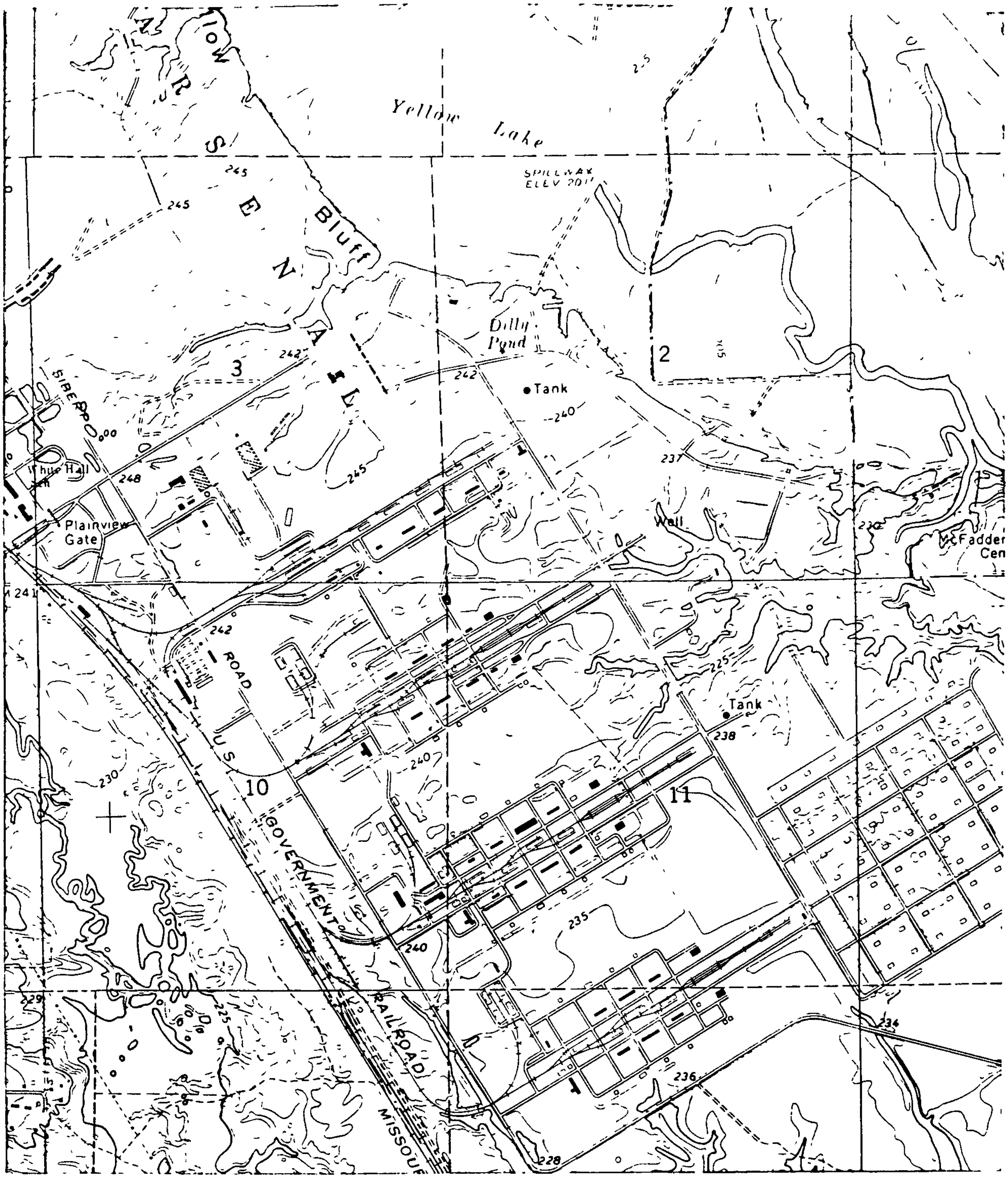
USGS map White Hall, Ark.

Scale: 1 inch = 2000 feet



Site 29a Salt Pile

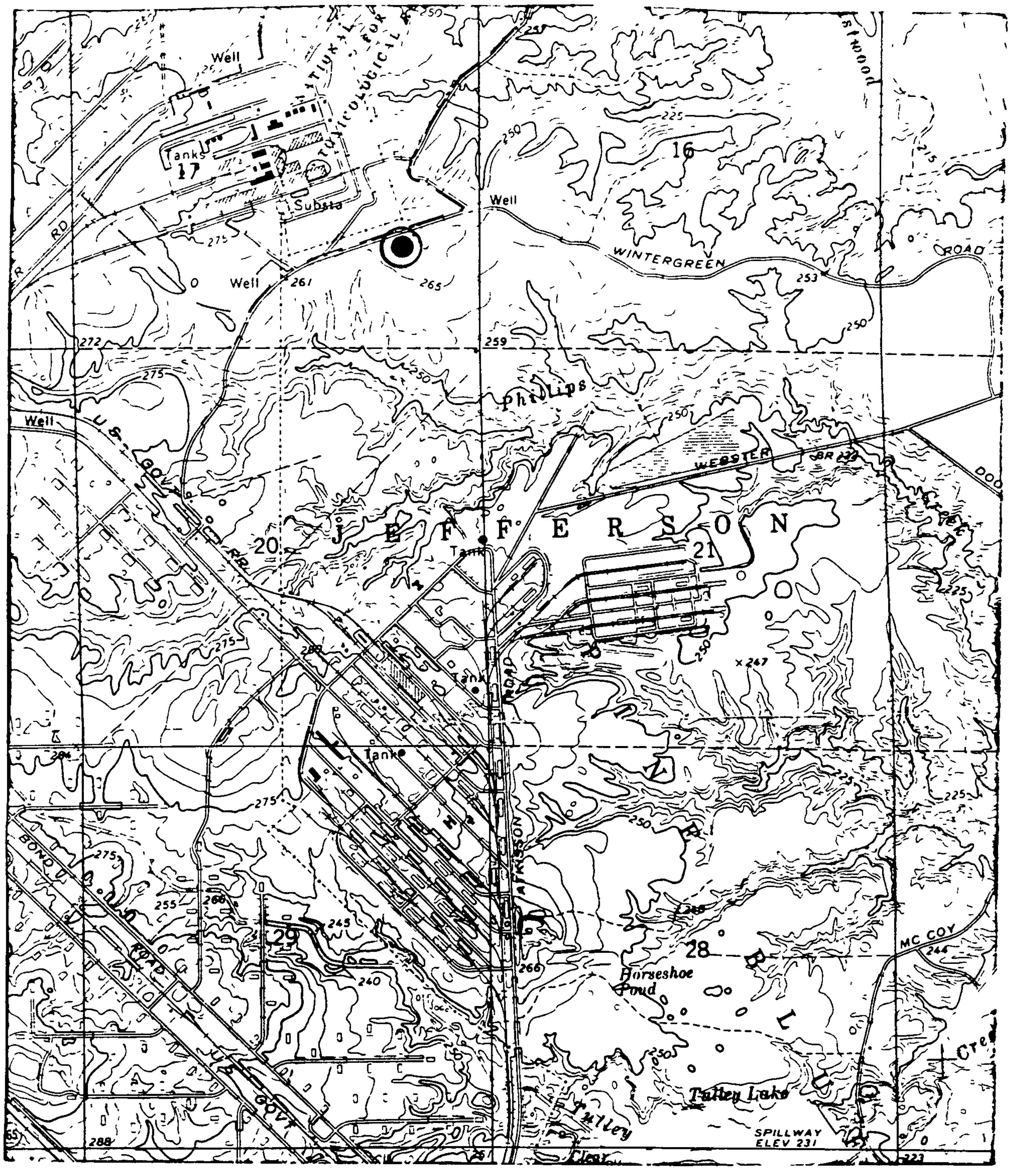
USGS



Site 31-b Grenade Test Basin

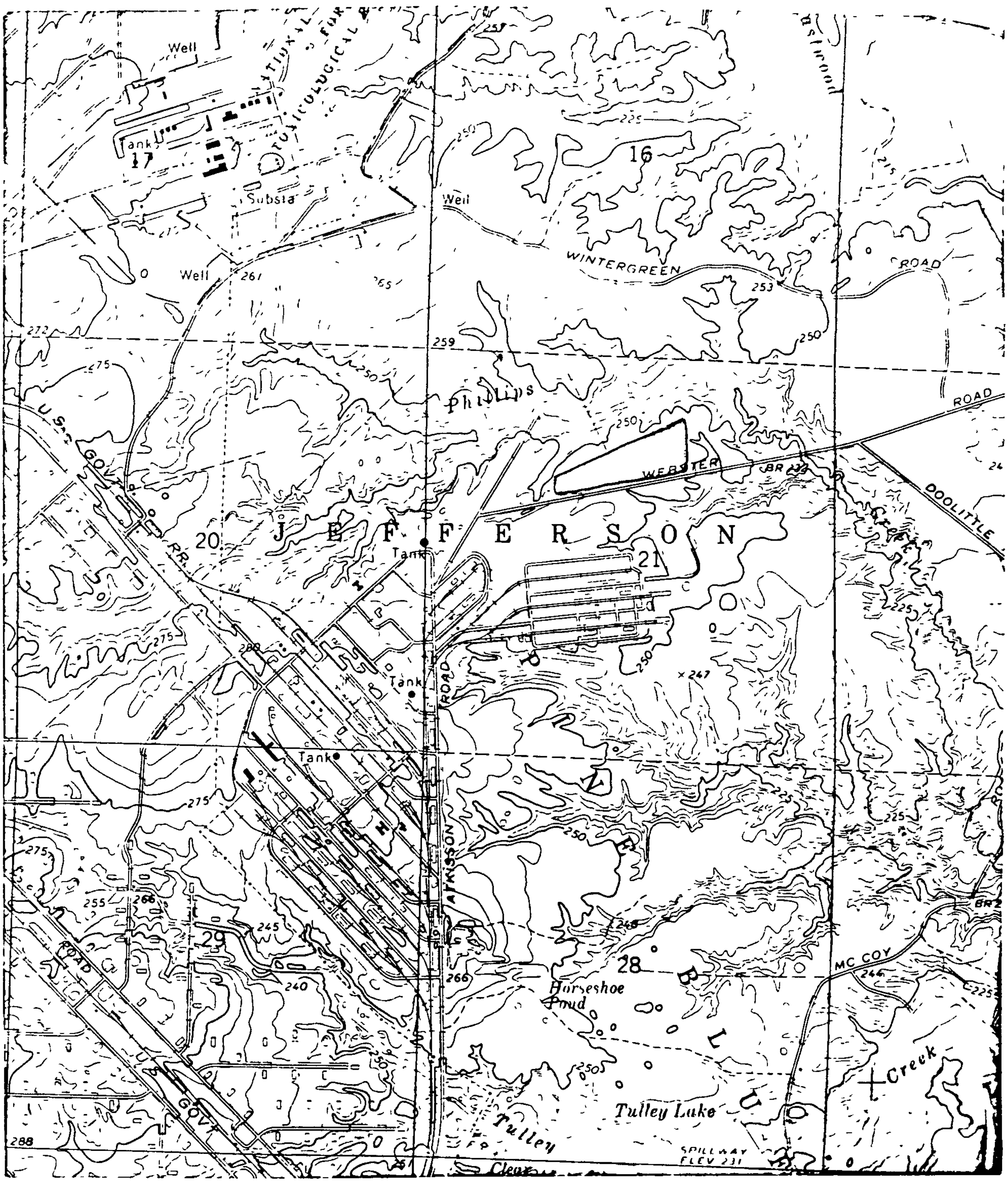
Scale: 1 inch = 2000 feet

USGS map White Hall, Ark.



Site 34 NCTR Equalization Pond

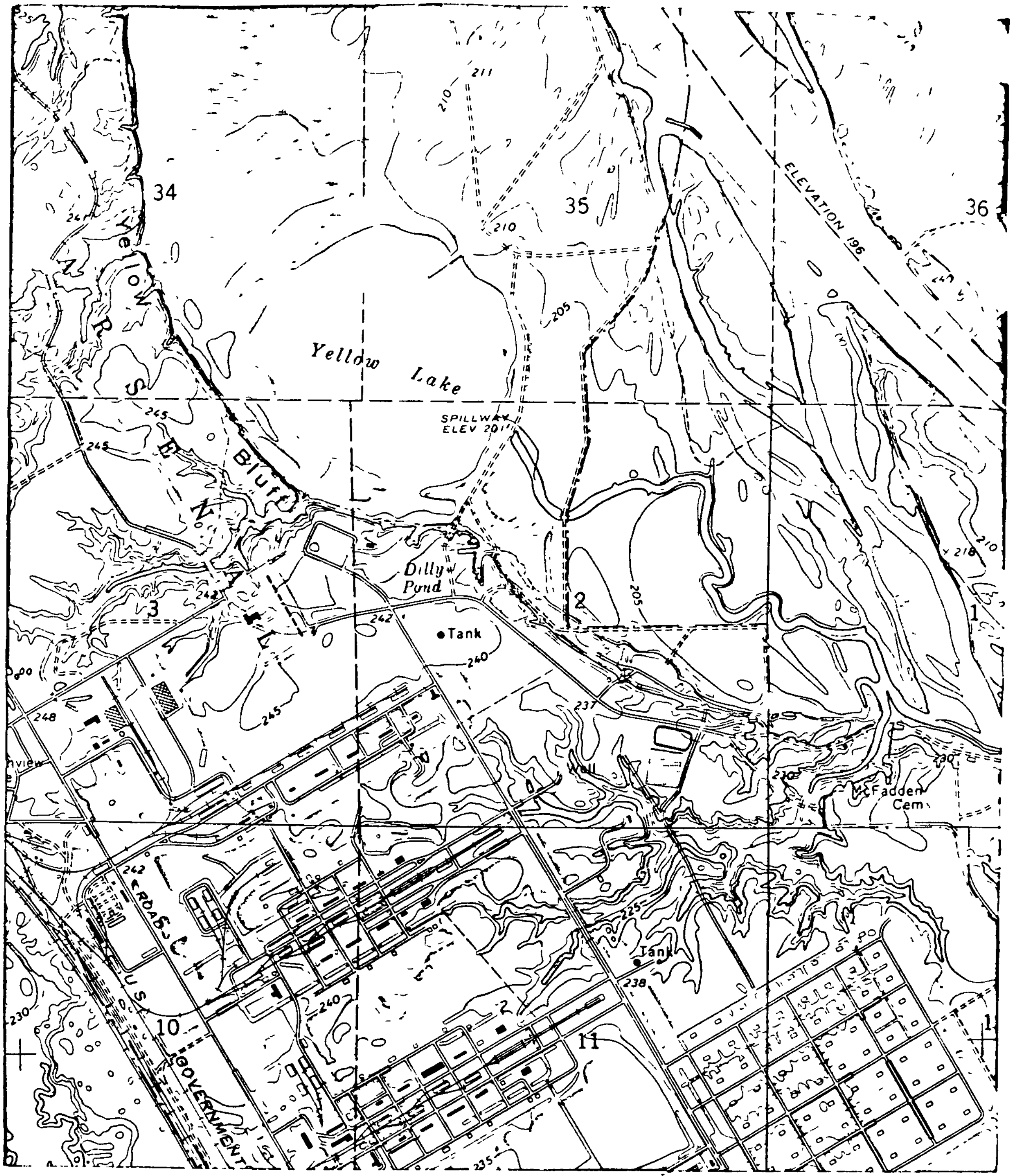
USGS



Site 35 North Oxidation Pond

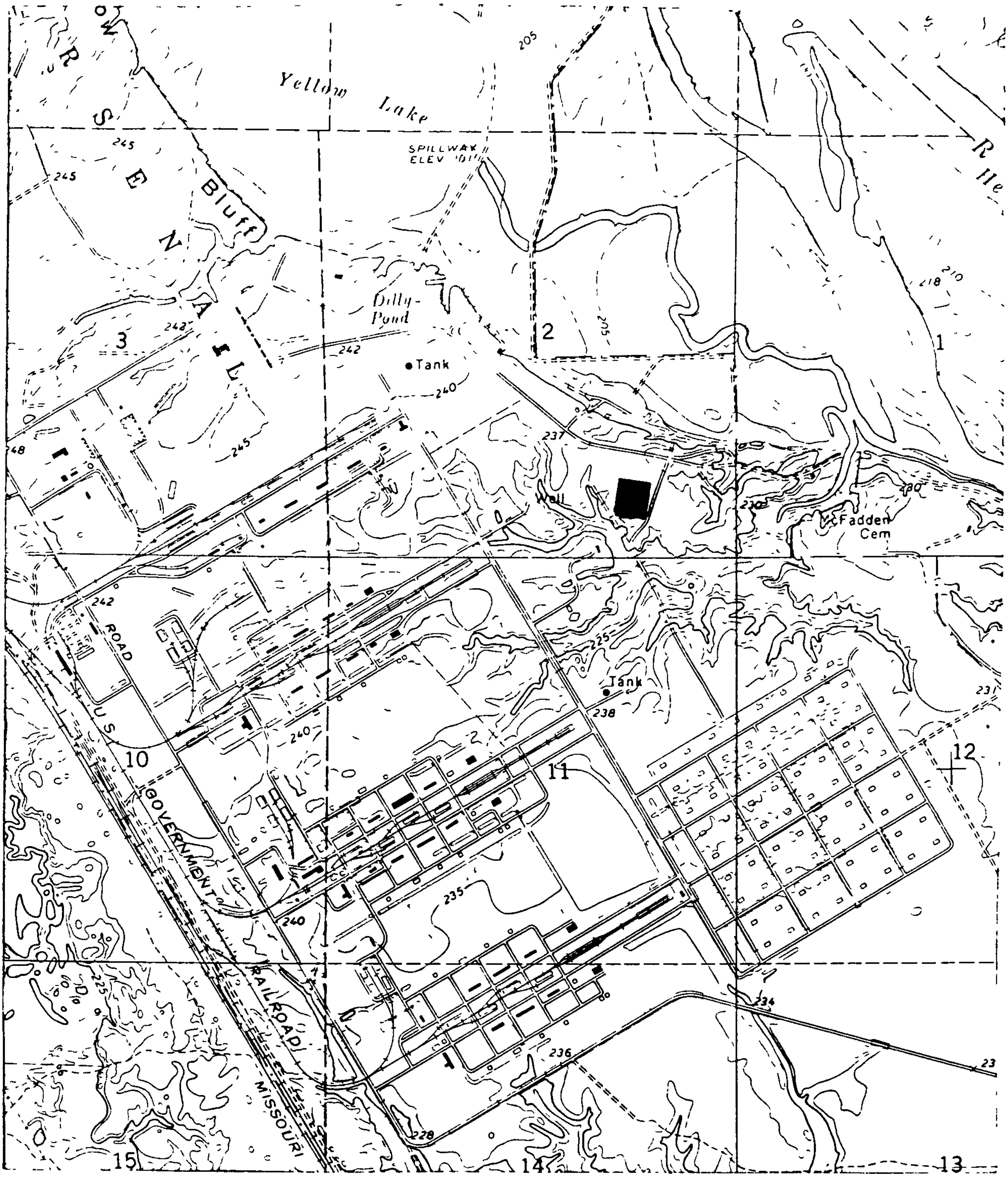
Scale: 1 inch = 2000 feet

USGS map White Hall, Ark.



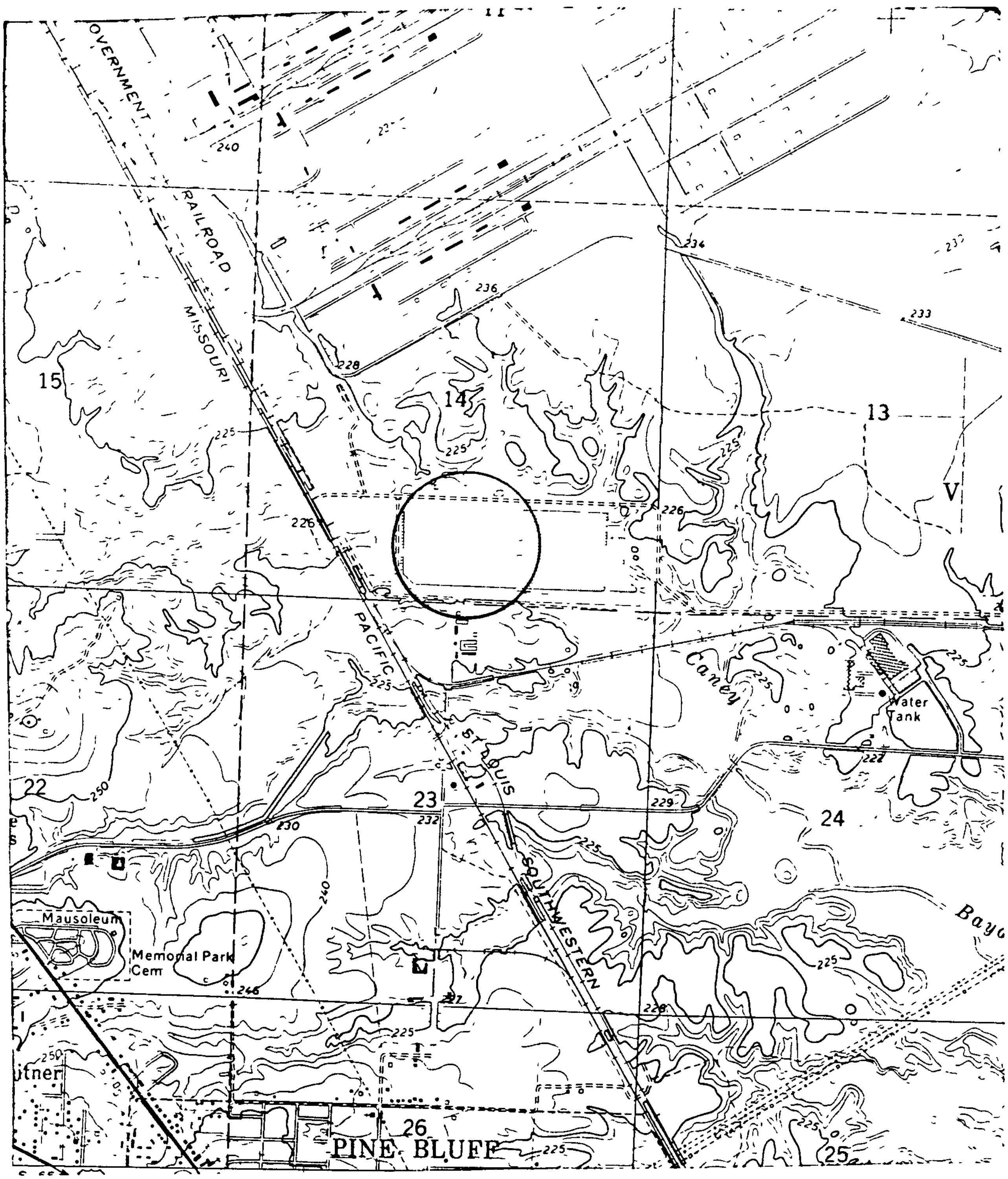
Site 36 Industrial Sludge Lagoon

Scale: 1 inch = 2000 feet USGS map White Hall, Ark.



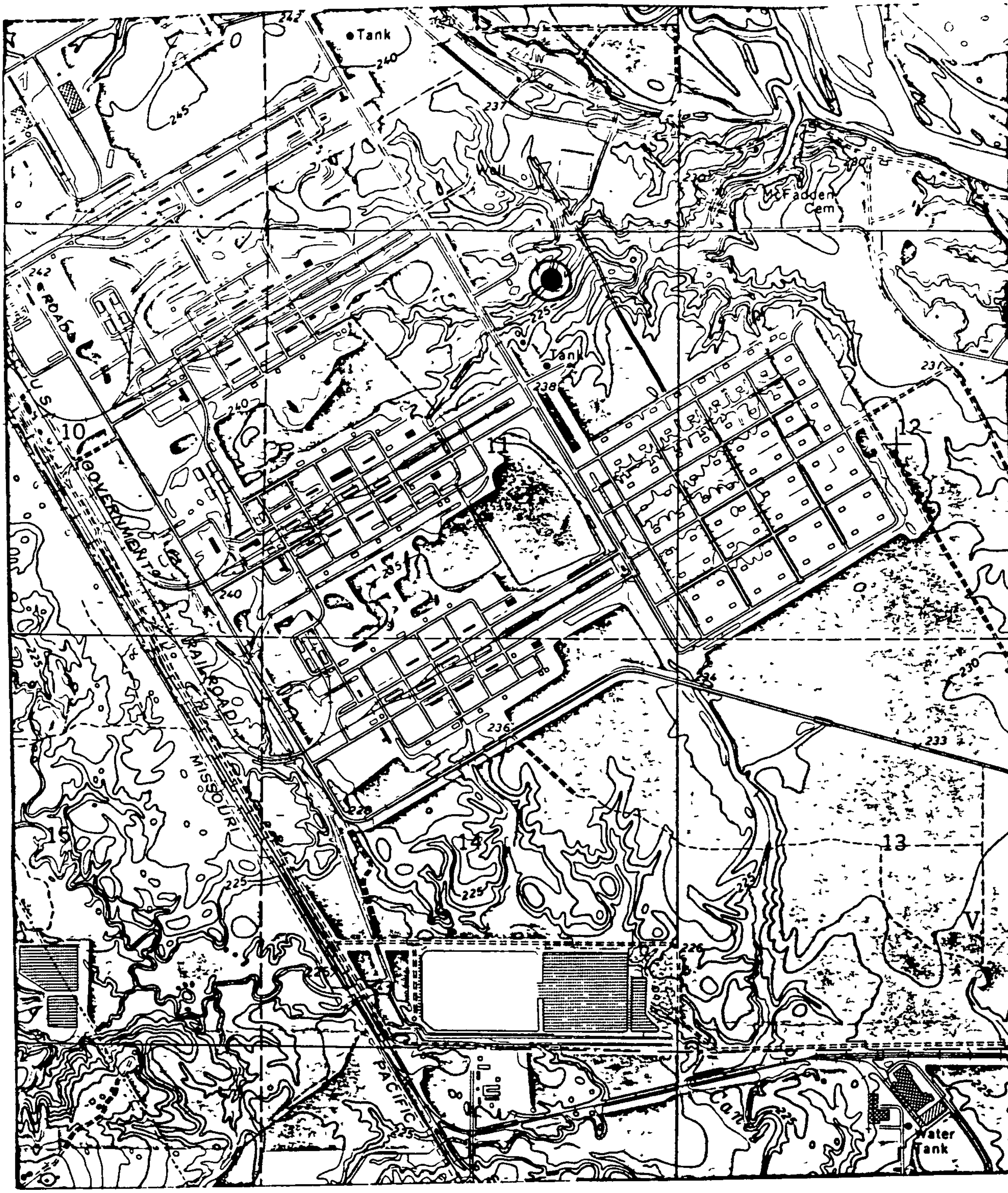
Site 37 South Oxidation Pond

Scale: 1 inch = 2000 feet USGS map White Hall, Ark.



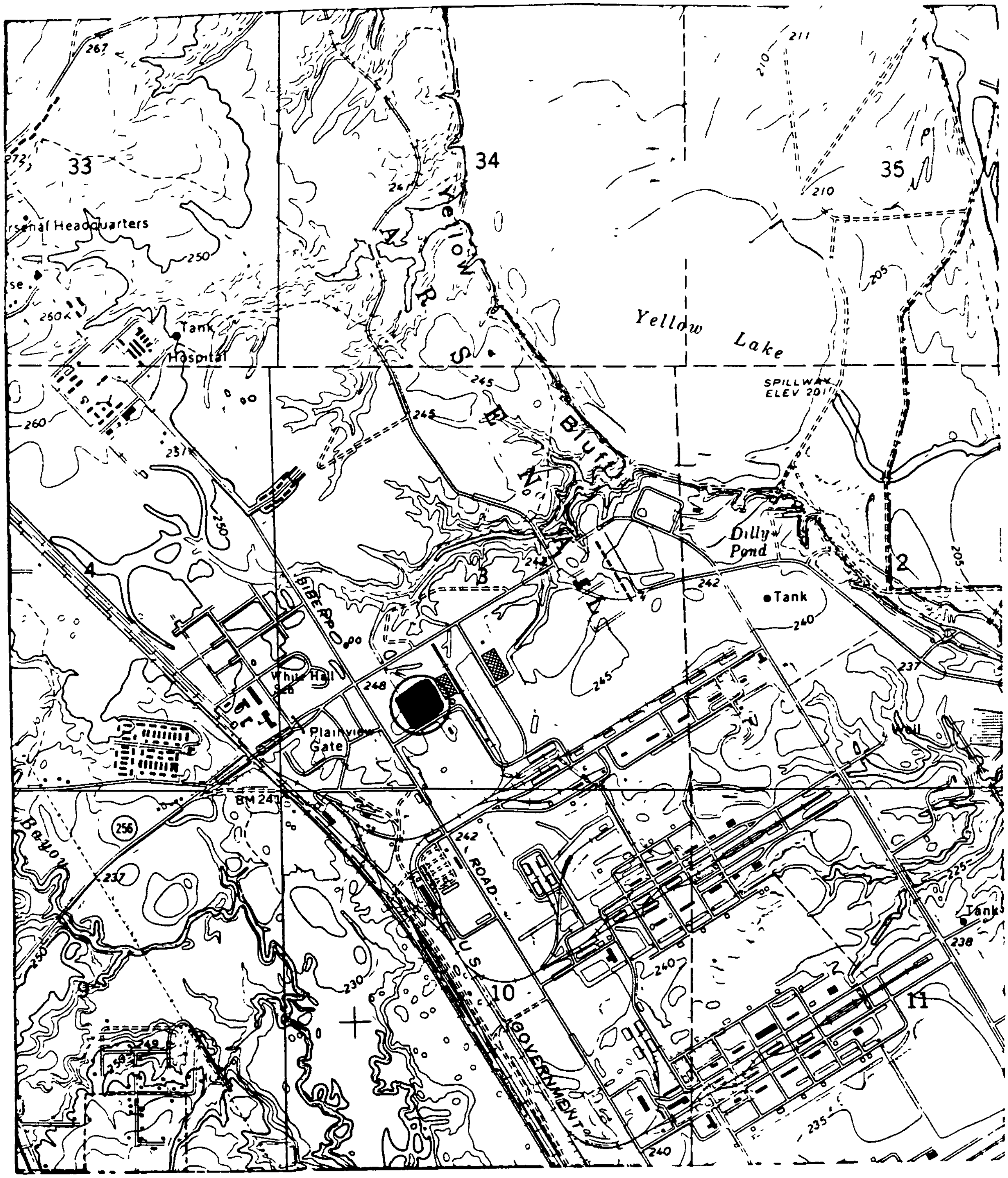
Site 39 Pine Bluff Oxidation Pond

Scale 1 inch = 2000 feet USGS map White Hall, Ark.



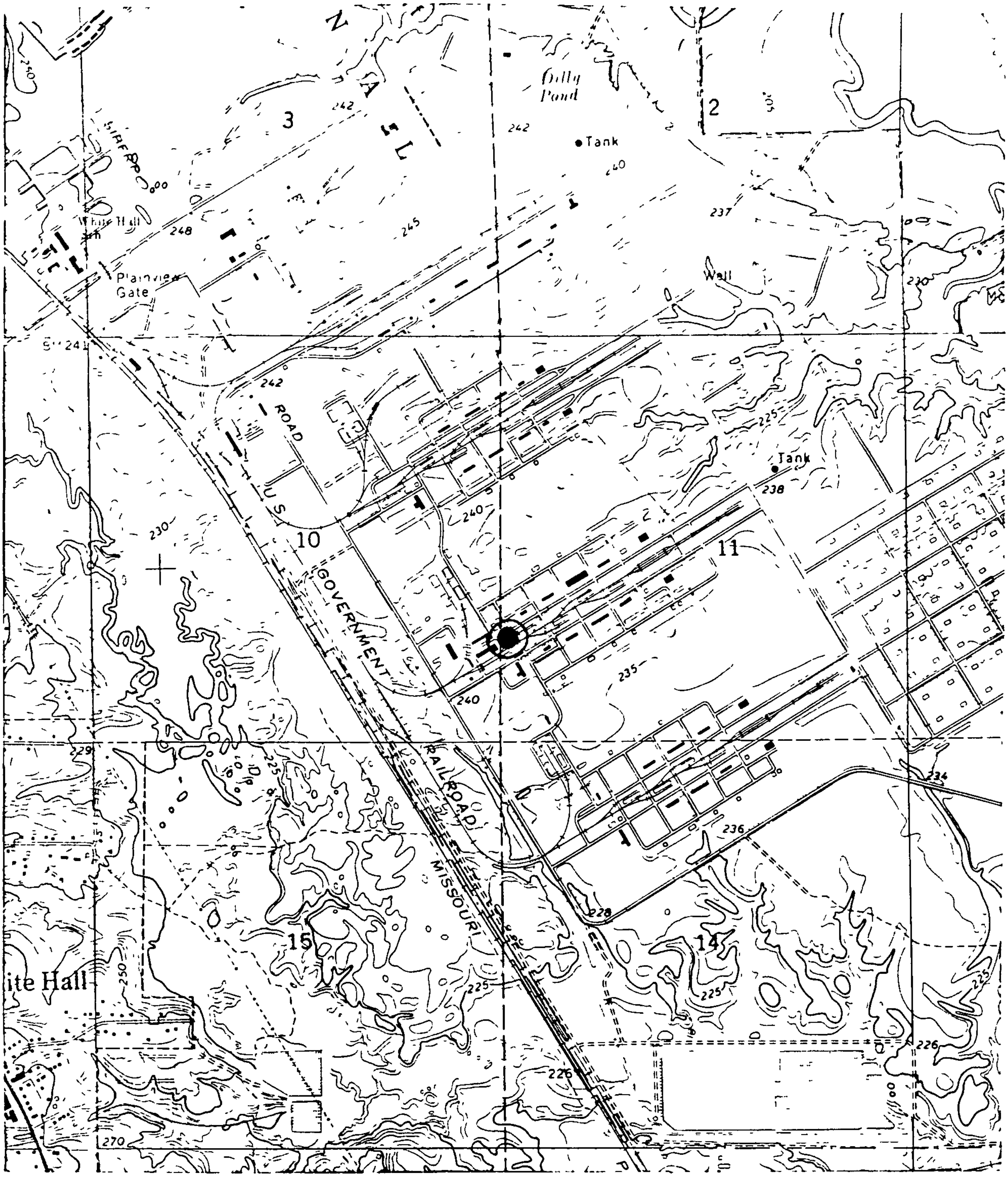
Site 42 Backwash Pond

USGS



Site 43 White Phosphorus Pollution Abatement Facility

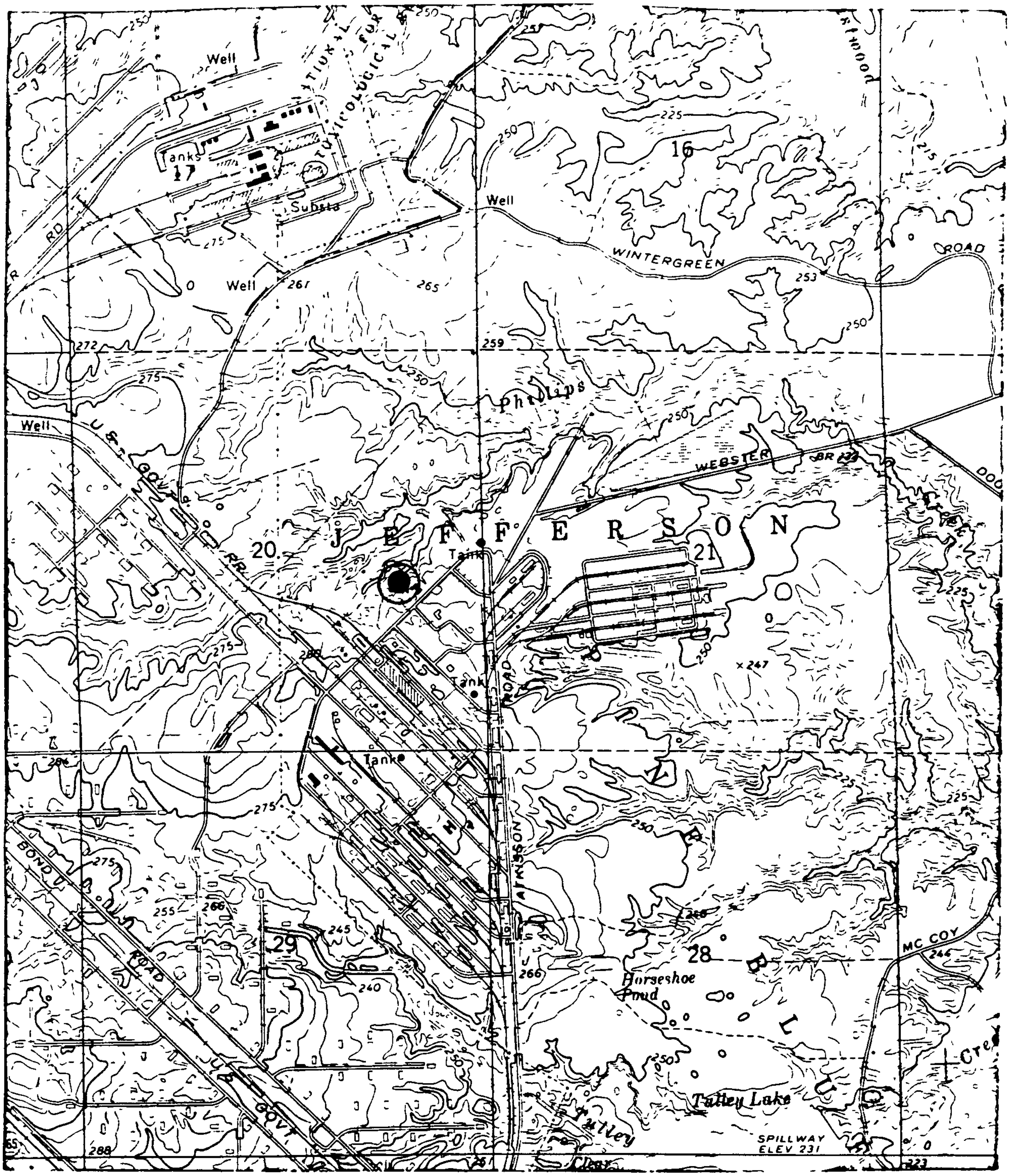
Scale: 1 inch = 2000 feet USGS map White Hall, Ark.



Site 38 Impregnite Sludge Pit

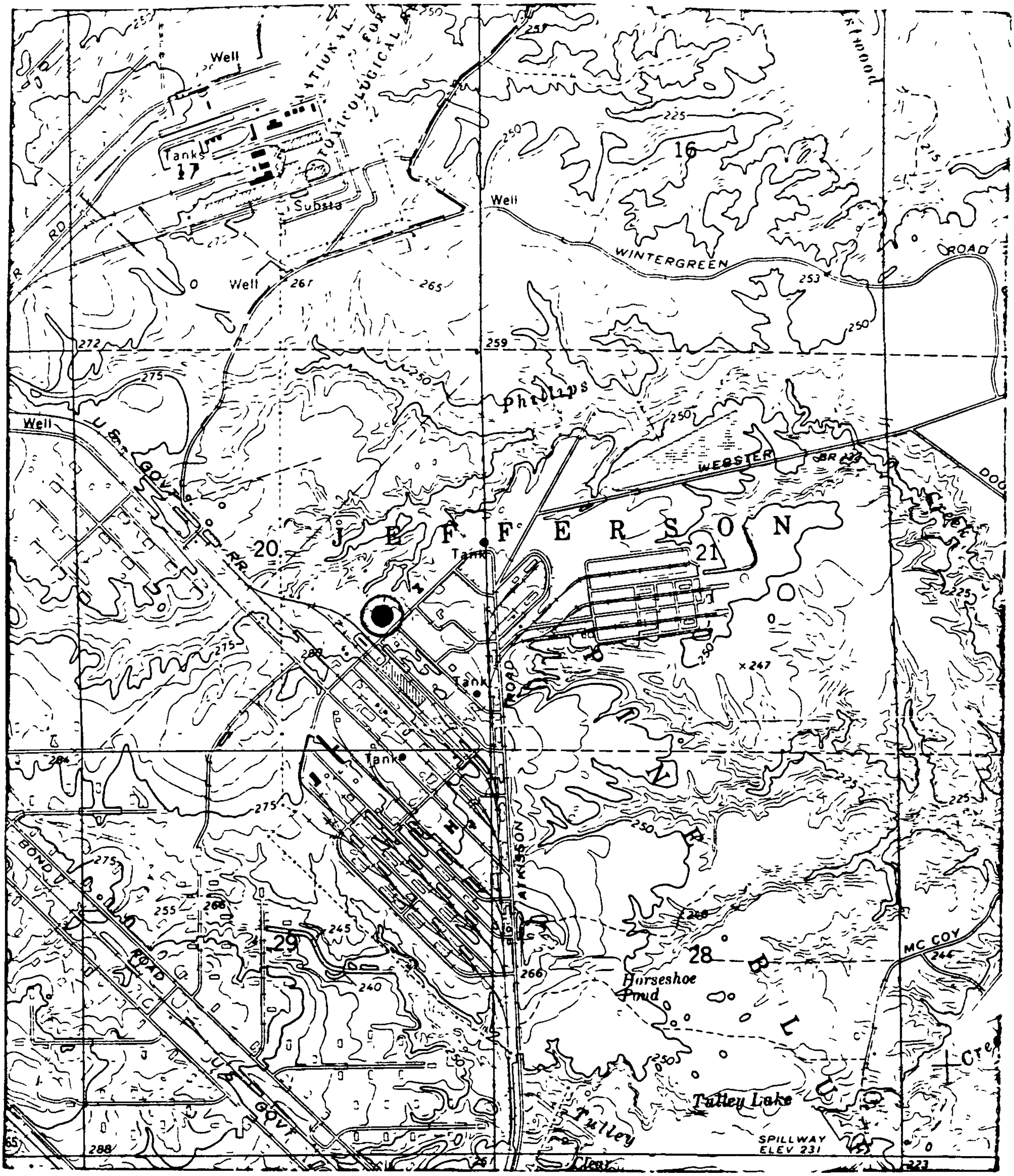
Scale: 1 inch = 2000 feet

USGS map White Hall, Ark.



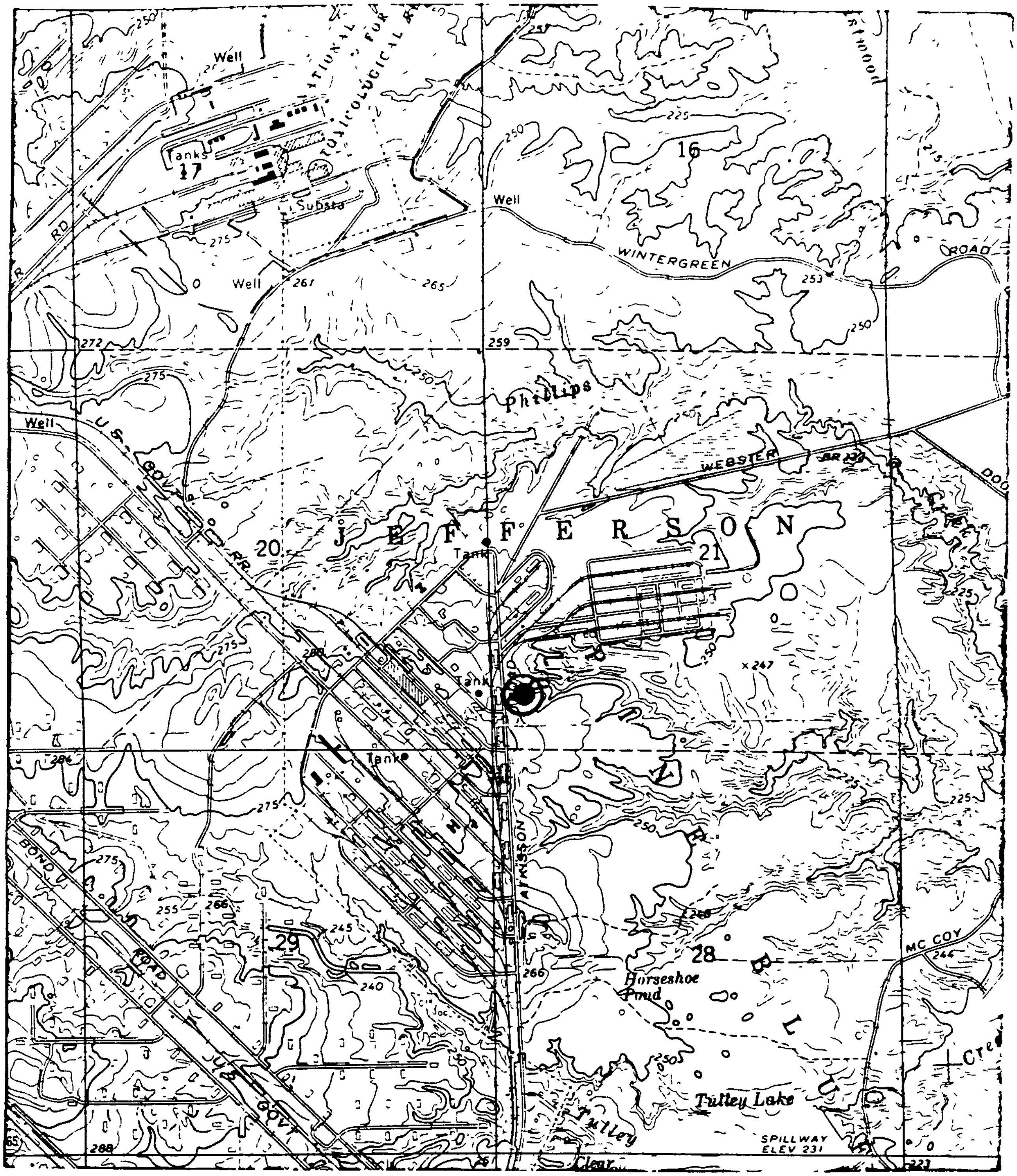
Site 11a Sediment Retention Basin # 1 (SRB-1)

USGS



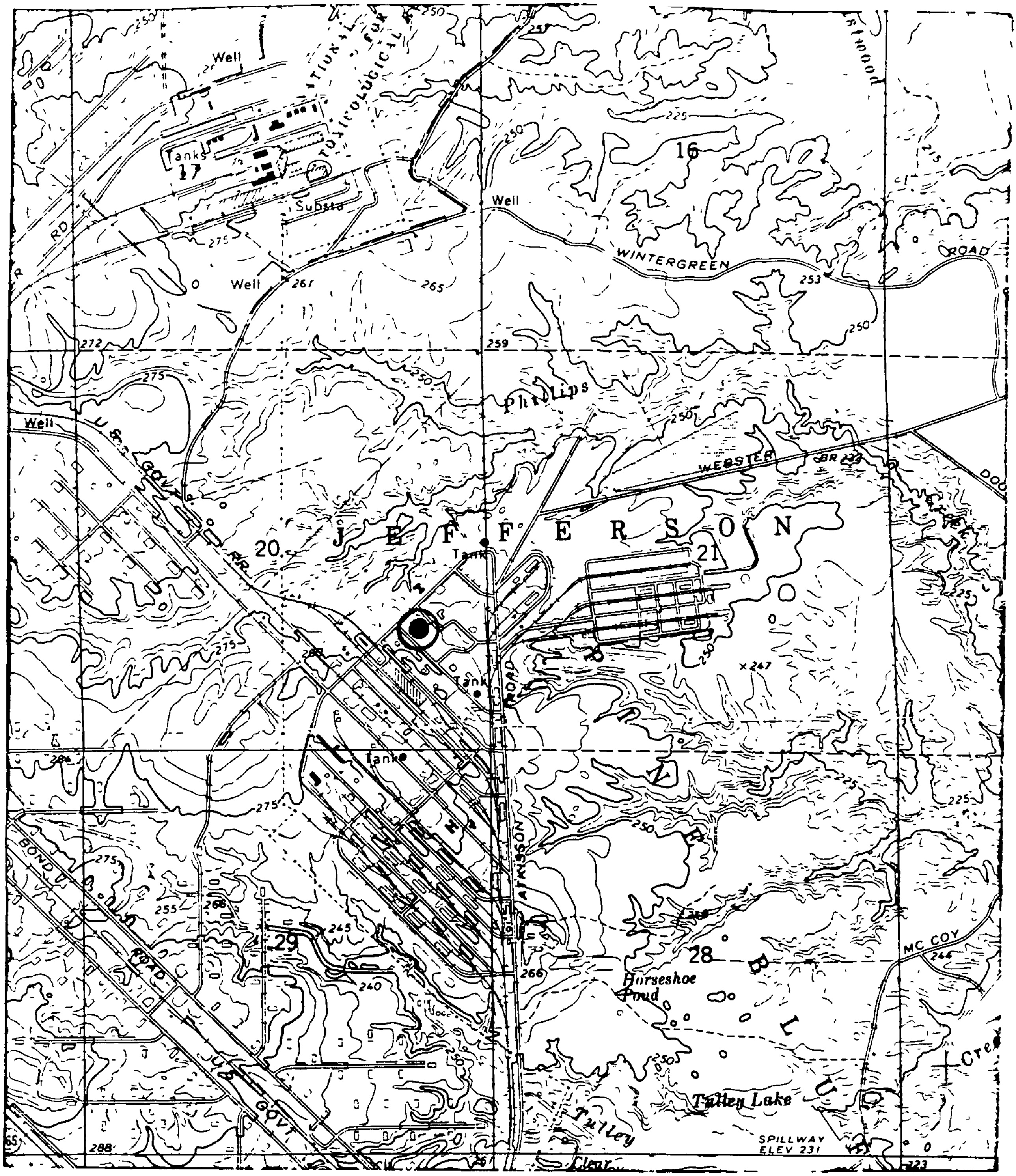
Site 11b Sediment Retention Basin # 2 (SRB-2)

USGS



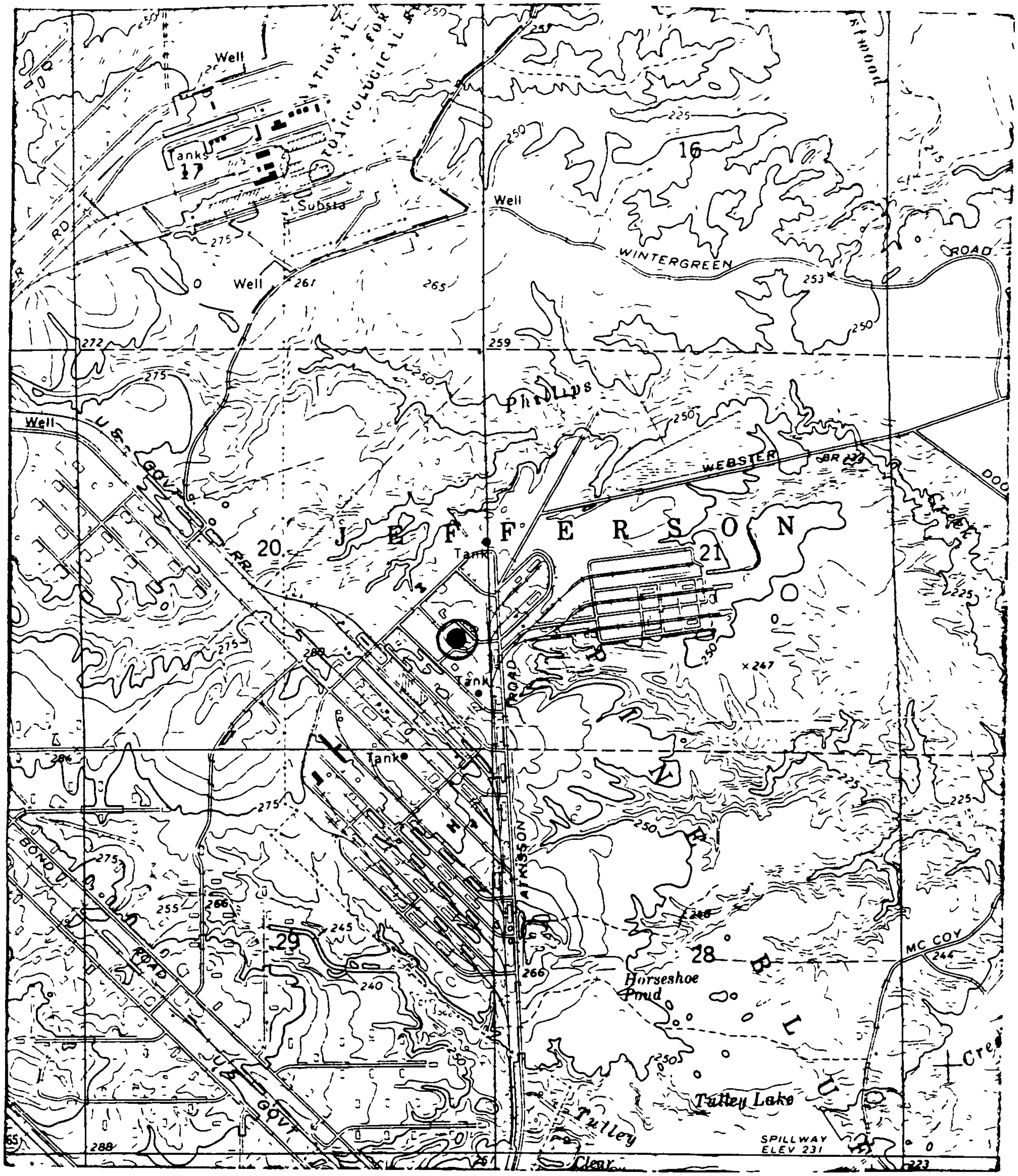
Site llc Sediment Retention Basin # 3 (SRB-3)

USGS



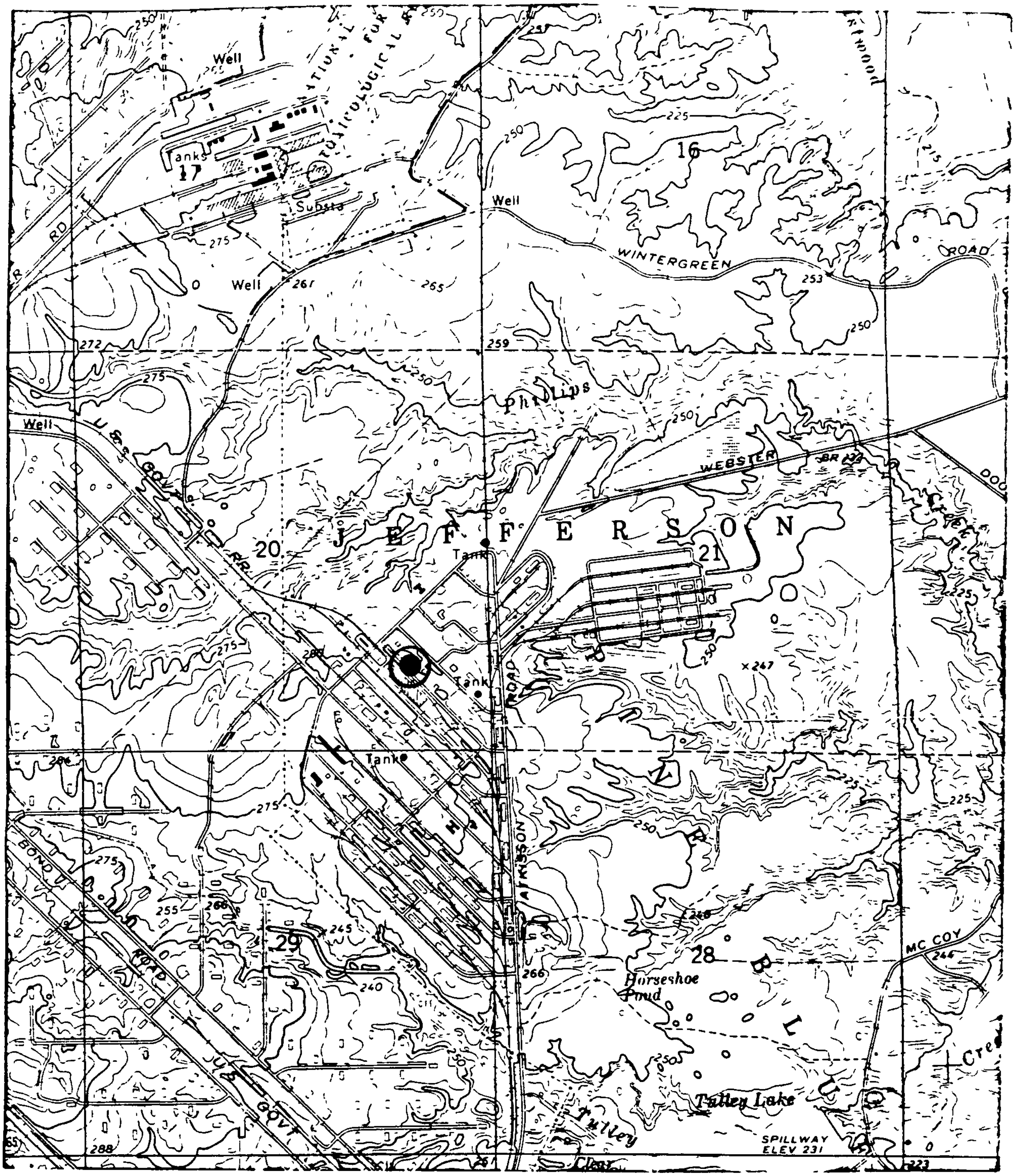
Site 11d DDT Storage in Basement, Bldg. 54-270

USGS.



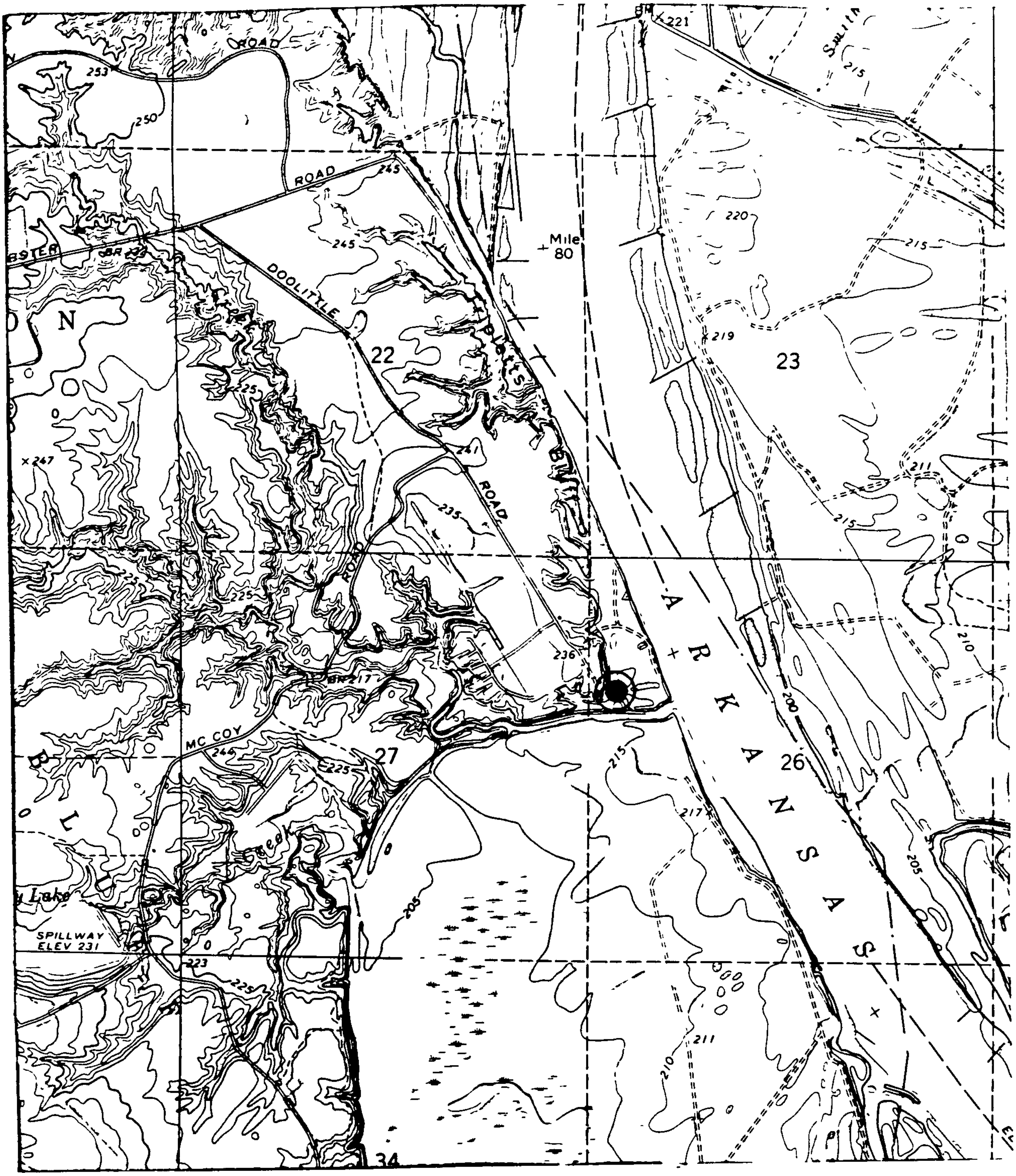
Site 11E DDT Basement Storage, Bldg. 54-325

USGS



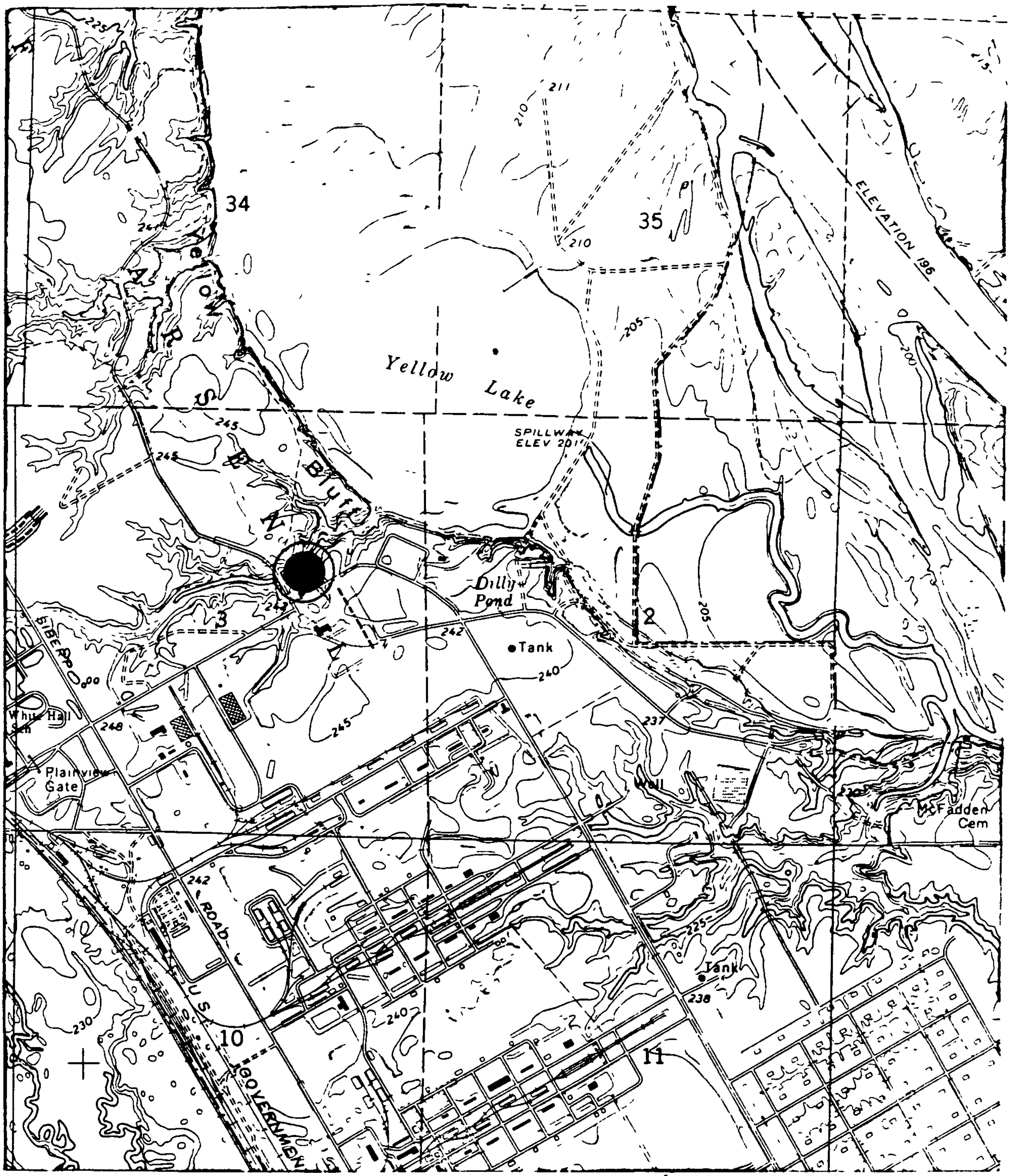
Site 11f DDT Waste Landfill

USGS



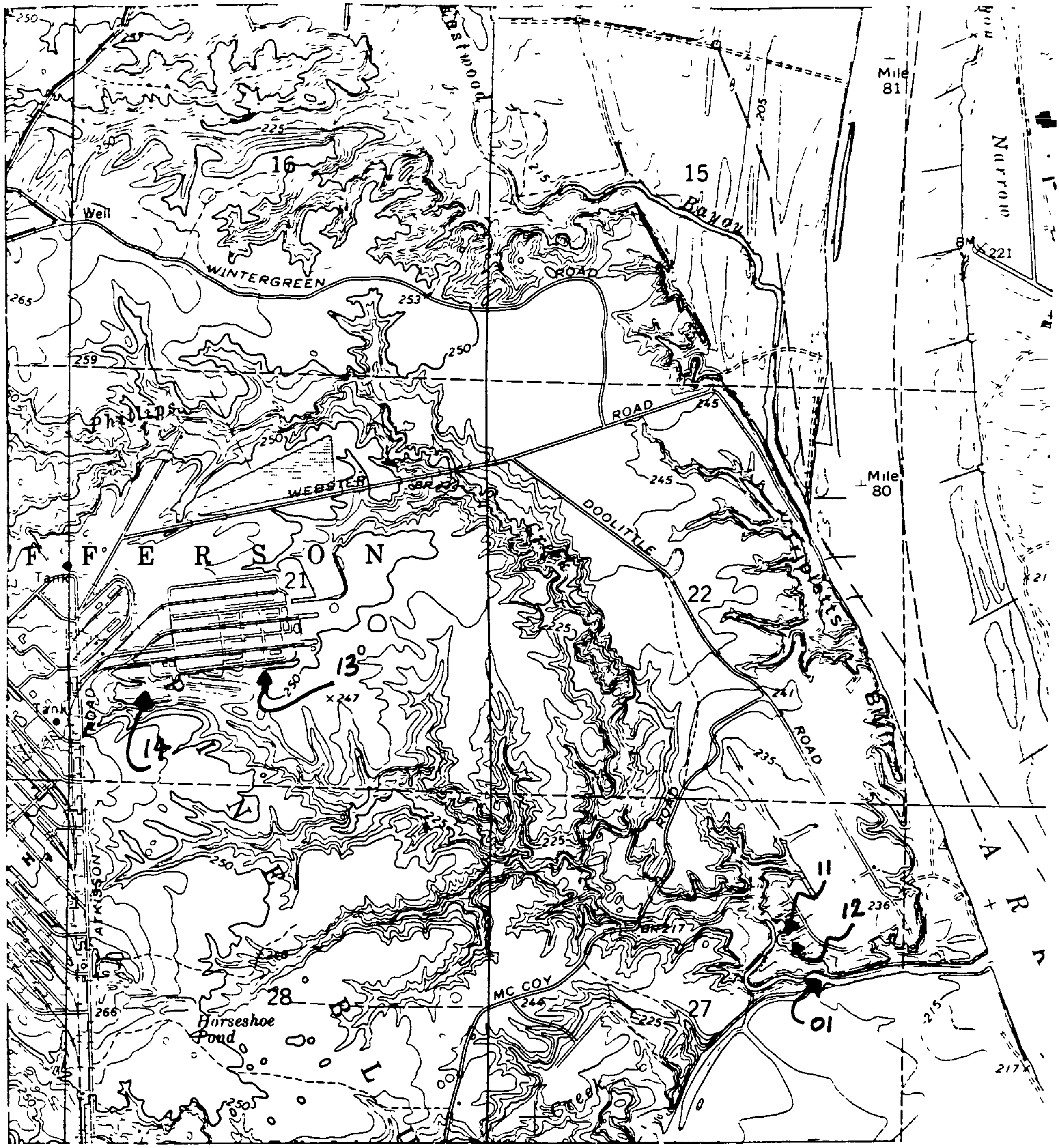
Site 12 Abandoned Mustard Burn Pits

USGS



Site 15 Sanitary Landfill

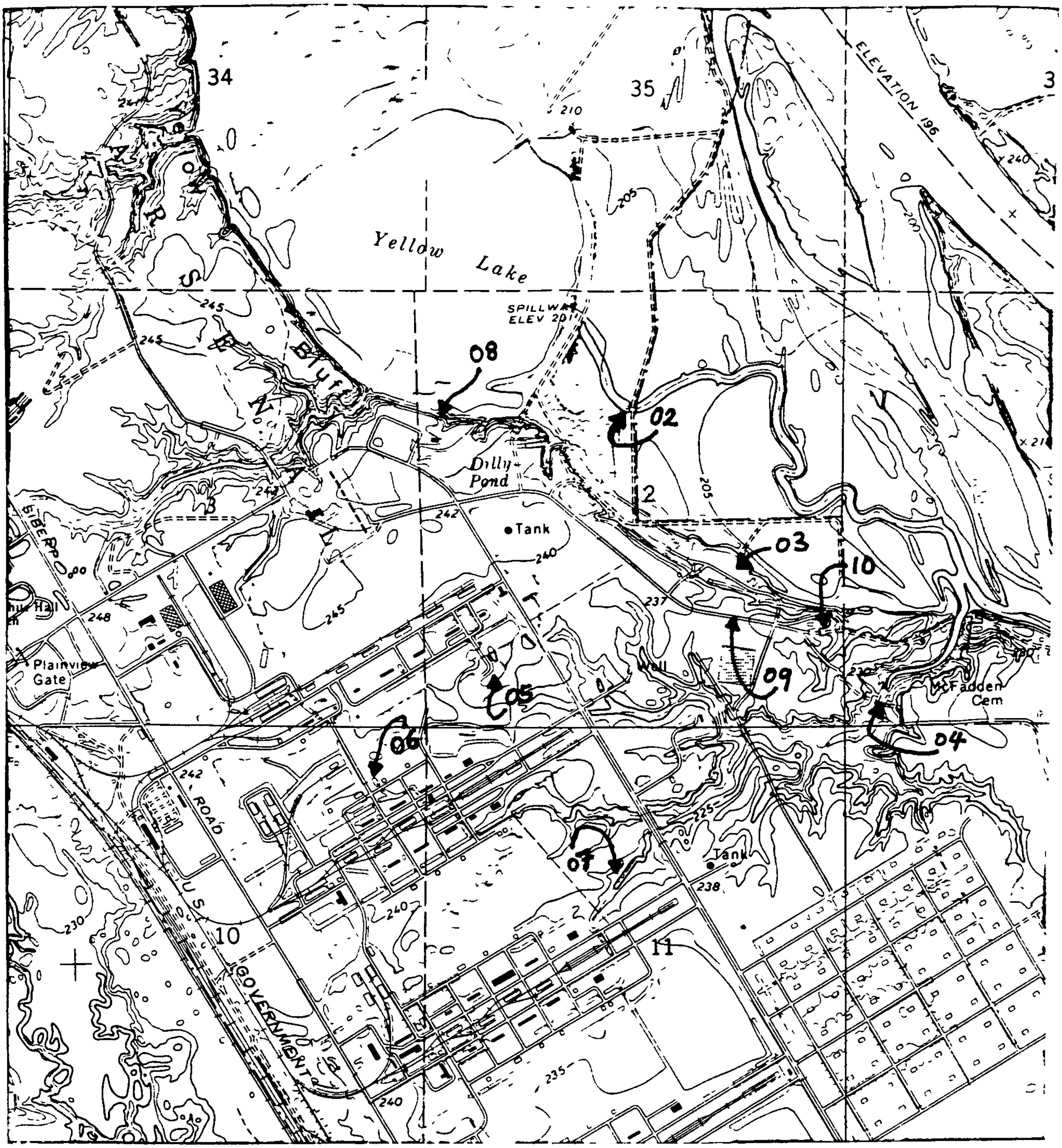
USGS



Sample Locations 01,11,12,13,14

Scale: 1 inch = 2000 feet

USGS White Hall, Ark.



Sample Locations 02,03,04,05,06,07,08,09,10

Scale: 1 inch = 2000 feet

USGS White Hall, Ark.

Photo Legend

Photos	Site	Photos	Site
1,2	16a	61	15
3,4	18a	62,63	27
5	18b	64,65	23
6,7,8	20b	66	Sample Location 01
9,10,11	24	67	Sample Location 02
12,13,14	26	68	Sample Location 03
15	29a	69	Sample Location 04
16,17	31a	70	Sample Location 05
18	31b	71	Sample Location 06
19	34	72	Sample Location 07
20,21	35	73	Sample Location 08
22	36	74	Sample Location 09
23	37	75	Sample Location 10
24	39	76	Sample Location 11
25,26,27,28,29	40	77	Sample Location 12
30	42	78	Sample Location 14
31	43	79	Sample Location 13
32,33	7b		
34,35	7c		
36,37,38,39	10		
40,41,42	20a		
43,44	38		
45,46,47,48	7a		
49,50	7d		
51,52	11a		
53,54	11b		
55,56	11c		
57	11d		
58	11e		
59	11f		
60	12		

ATTACHMENT A

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT SUPPLEMENT SHEET

Instruction - This sheet is provided to give additional information in explanation of a question on the form T2070-3.

Corresponding number on form	Additional Remark and/or Explanation
IVA.3.	Samples Collected on 18, 19 June 1981.
	Samples were collected along possible run-off pathways within the arsenal and from several streams/swamps situated near the arsenal boundary. They are listed below:
	Aqueous Samples
	Location 01 - Phillip's Creek confluence with Arkansas River (photo 66)
	✓ Location 02 - Yellow Lake discharge at arsenal boundary (photo 67) site 11
	Location 03 - Site 20a; 800 ft. east of entrance road (photo 68)
	Location 04 - Production Creek, 1470 ft. southwest of arsenal boundary (photo 69)
	Soil/Sediment Samples
	nothing ✓ Location 05 - Site 23a; 270 ft. 71° from south end of pond (photo 70)
zinc (24 ppm)	✓ Location 06 - Site 31a; 133 ft. 255° from "goat shed" (photo 71)
nickel 281 ppm	✓ Location 07 - Site 24; 412 ft. 196° from entrance (photo 72)
DDT 0.635 ppm	Location 08 - Site 17; 20 ft. from Yellow Lake, 33° from bldg. 544-220 (photo 73)
nothing	✓ Location 09 - Site 40; 50 ft. 275 ° from bldg. 42-823 (photo 74)
lead	✓ Location 10 - Site 20b; 35 ft. 100° from east end (photo 75)

ATTACHMENT A

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT SUPPLEMENT SHEET

Instruction - This sheet is provided to give additional information in explanation of a question on the form T2070-3.

Corresponding number on form	Additional Remark and/or Explanation
(Con't. of IV.A.)	**Soil/Sediment Samples** Location 11 - Site 10; Trench #3, 160 ft. toward Phillip's Creek (photo 76) Location 12 - Site 10; Trench #4, 290 ft. toward Phillip's Creek (photo 77) Location 13 - Site 7c; 20 ft. west of site along stream (photo 79) Location 14 - Site 7b; 30 ft. west of dam on east edge (photo 78)
VIII.U.	**Proposed Sampling Plan** (See I.i. and Supplemental Reports) Soil Samples: Site 7a (Toxic Storage Yard) Sample from several erosional gullies along southern boundary to determine off facility contamination (organics/inorganics). Site 12 (Abandoned Mustard Burn Pits) Several samples from downslope areas to determine extent of surficial contamination (inorganics). Aqueous Samples: Site 7d (TSY Borrow Pits) North, south pits - analyzed for organics and inorganics. Sites 11a, 11b, 11c, 11d, 11e, 11f, (DDT Areas) Samples collected from WES wells No. 43, 44, 45, 46, 53, 62 and 67- analyzed for pesticides. Site 15 (Sanitary Landfill) Samples collected from WES wells No. 15 and 16 - analyzed for organics and inorganics.

ATTACHMENT A

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT SUPPLEMENT SHEET

Instruction - This sheet is provided to give additional information in explanation of a question on the form T2070-3.

Corresponding number on form	Additional Remark and/or Explanation
(Con't. of VIII.U.)	Aqueous Samples: <u>Site 23 (White Smoke Test Pond)</u> Sample collected from pond - analyzed for inorganics/pH. Combination Aqueous/ Sediment: <u>Site 27 (Agent BZ Pond)</u> Upstream/downstream water/sediment samples from small stream north of site - analyzed for inorganics. <u>Proposed Monitoring Well Installation</u> The FIT recommends that monitoring wells (1 upgradient, 3 downgradient) be installed at the following sites to determine whether or not groundwater contamination has occurred: Site 7b, Lewisite Disposal Site Site 7c, Mustard Burn Yard Site 10, Depot Burning and Demolition Area Site 17, Product Assurance Test Range and Dumpsite Site 20a, Depot South Burn Pit and Storage Area Site 23, White Smoke Test Pond Site 38, Impregnite Sludge Lagoon Site 12, Abandoned Mustard Burn Pits Site 27, Agent BZ Pond

PRE-SCORE

REFERENCE 7

HYDROGEOLOGICAL SURVEY OF PINE BLUFF ARSENAL

by

Jerald D. Broughton

U. S. Army Engineer Waterways Experiment Station
P. O. Box 631, Vicksburg, Mississippi 39180

PREFACE

This study was performed by personnel of the Geotechnical Laboratory (GL) of the U. S. Army Engineer Waterways Experiment Station. Funding for this study was authorized by Interagency Order (IAO) Nos. FJ7 P185901 FJQ6, FJ7 P187101 FJQ6, and FJ7 P1870 FJQ6 from Pine Bluff Arsenal (PBA), Pine Bluff, Arkansas, and IAO Nos. 6P241, 48-9-P140 M1-Q6, and 80-D-11 from the U. S. Army Toxic and Hazardous Materials Agency (USATHAMA) (formerly Project Manager for Chemical Demilitarization and Installation Restoration), Aberdeen Proving Ground, Maryland.

The field work was conducted during the periods 16 Febraury to 4 August 1977 and 2-21 November 1978. Soil testing and data reduction were performed during 1978 and 1979 and report preparation was accomplished during the period February to August 1980. The drilling was performed by the Exploration Group, Engineering Ceology and Rock Mechanics Division (EGRMD), GL, under the supervision of Mr. Jerald D. Broughton, Engineering Geology Applications Group (EGAG) of the EGRMD. The physical soil tests were performed by the Soil Testing Facility, GL. Personnel of EGAG accomplished the data compilation and analysis. Mr. Broughton prepared the report.

The study was conducted under the direct supervision of Mr. John H. Shamburger, Chief, EGAC, and under the general supervision of Dr. Don C. Banks, Chief, EGRMD, and Messrs. James P. Sale and Richard G. Ahlvin, Chief and Assistant Chief, GL, respectively.

Special acknowledgment is extended to the following individuals for their assistance during the study--Messrs. Thomas E. Shook and Glen Murtha of PBA and Mr. Richard Hervert, formerly of USATHAMA, and numerous other personnel from PBA and USATHAMA.

Commanders and Directors of WES during the conduct of the study were COL John L. Cannon, CE, and COL Nelson P. Conover, CE. The Technical Director was Mr. F. R. Brown.

CONTENTS

WORKING DRAFT

HYDROGEOLOGICAL SURVEY OF PINE BLUFF ARSENAL

PART I: INTRODUCTION

Background

Pine Bluff Arsenal (PBA) is located in Jefferson County, Arkansas, approximately 13 kilometres (km) northwest of the county seat, Pine Bluff, (see Figure 1), and approximately 48 km from Little Rock. The Arsenal is bounded on the east by the Arkansas River and on the west by the Missouri-Pacific Railroad. Industrial developments are to the south, and the northern perimeter is adjacent to woodlands and the National Center for Toxicological Research (NCTR). The PBA extends some 15 km in a northwest-southeast direction and is approximately 4 km wide. These 6000 hectares (ha) are used for administration, housing, and operations (80 ha); security and storage (790 ha); forest products (4430 ha); and primitive area preservation (700 ha) (Pinkham, C.F.A., et al, 1975).

The PBA was established in 1941 to manufacture, load, and assemble chemical and incendiary munitions. The initial mission involved magnesium and thermite types but was expanded to manufacture war gases and to fill chemical bombs, incendiary smoke munitions, and other munitions with chemicals such as chlorine, mustard, and lewisite. Subsequent operations have included the manufacturing, loading, and assembling of incendiary bombs, smoke grenades, smoke pots and canisters, white phosphorous, FS (sulfur trioxide chlorosulfonic acid solution), BZ (3-Quinuclidinyl Benzilate), and biological agents. Full-scale incendiary and chemical munitions operations were conducted during 1941-1945 and 1950-1953. The biological operations were conducted during 1953-1969; biological demilitarization was completed in 1972.

Limited operations were conducted at PBA during 1946-1949 and 1954 to the present. During portions of this time civilian contractors leased facilities for the manufacture of chlorine, DDT, malathion,

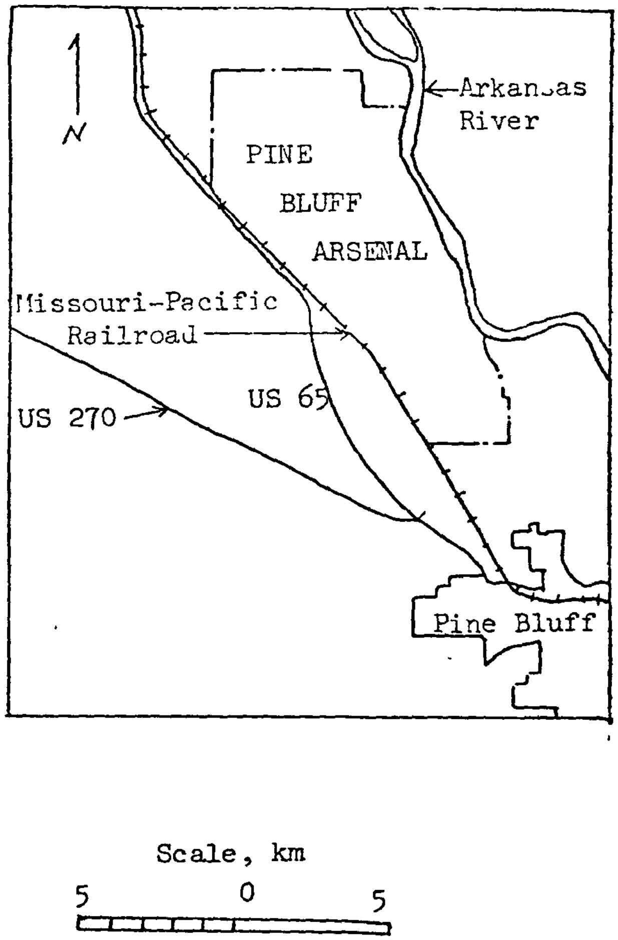


Figure 1. Location map for Pine Bluff Arsenal

parathion and chlorobenzenes (Pinkham, C.F.A., et al, 1975). Surface disposal of toxic materials was practiced during the Government and contractor operations which resulted in DDT, dyes, and incendiaries being spread on the surface at disposal sites.

Previous Studies

Groundwater contamination at other U. S. Army installations and knowledge of prior activities at PBA resulted in a data collection and analyses program to describe and define any contamination migration problems at the PBA. The first of these efforts (Lachapelle, David G., Brooks, Alan E., and Trescott, Edward B., 1969) was to locate, develop, and sample points to identify known locales of contamination or to establish baseline data to be used to compare future conditions. Table 1 and Table 2 show the multitude of materials used at the PBA and the materials and locations selected for monitoring, respectively. Figure 2 shows the locations of the monitoring wells for this study. Note that wells 1 and 2, in the vicinity of well 3, were not completed as monitoring wells and are not shown on the location map. This study concluded that the groundwater from wells 4 and 17 was contaminated because of their higher chemical oxygen demand (COD), sulfate, total and filterable residue, and chloride values; wells 5, 6, and 16 had phosphorous levels higher than those of the other wells; and wells 14, 15, and 17 had higher than average nitrate values. The study recommended that sampling be continued at these wells to provide the information required for diligent pollution control.

A survey conducted during 2-6 March 1970 by the U. S. Army Environmental Hygiene Agency (USAEHA) addressed surface water contamination with domestic, solid, and industrial waste and found several perennial or intermittent streams carrying contaminants from all categories of waste. Untreated sewage, grease, white phosphorous, and film processing waste were being discharged into surface waters. Sample locations are shown on Figure 2. No reference was made to the potentiality of these contaminants

Page 6 removed------see original.

entering the groundwater. The groundwater monitoring report (Lachapelle, et al, 1969) was quoted as determining that the only significant pollution was by chlorine at wells 4 and 17. The PBA was continuing the groundwater monitoring program.

The USAEHA conducted a groundwater and surface water monitoring program at the PBA in 1972 (USAEHA, 1973). This survey used the sampling points established during previous surveys. This survey identified contaminants in the groundwater (COD higher than 1968 baseline data) and surface water (suspended solids, phosphates, excessive biological oxygen demand and elemental phosphorous), but no phosphates were detected in the groundwater. Chlorine was found to be migrating from the northern area even though the contractor operations had ceased. The survey recommended that the surface waters be analyzed for lead, barium, and zinc because small quantities of these elements were used and were probably discharged on the ground surface. As recommended, PBA selected approximately 30 locations for detailed analysis of surface runoff, soils, and groundwater. Preliminary analysis was completed at several locations.

The Water Quality Geohydrologic Consultation (USAEHA, 1974) expressed specific interest in the shallow aquifer in the Quaternary terrace deposits. This aquifer was described as occurring at an elevation of 58-59 m above mean sea level averaging 12 metres (m) thick and having a permeability of 7.78×10^{-2} centimetres per second (cm/sec). Recharge was attributed to influent streams and groundwater movement was to the east. Increasing COD levels from the 1968 baseline data were concluded to be a significant contributor to pollution and recommendations were made for additional groundwater monitoring points, in the southeast portion of PBA, and additions and deletions to the suite of tests for potential contaminants. The groundwater sample points are shown on Figure 2.

A comprehensive survey (Pinkham, Carlos F.A., et al, 1975) conducted in 1972, addressed the geographic setting and physical characteristics of the PBA as background for wildlife descriptions and evaluations of soil, surface water and air pollution. This survey concluded that surface waters were highly contaminated, surface soils were less contaminated, and air pollution was practically non-existent. These conclusions were based on the surface water quality monitoring sites and the contaminated surface soil sites shown on Figure 2. Groundwater was not considered in the environmental survey but the verified presence of contaminated areas of surface soil and water indicated a potential for the movement of contaminants through the subsurface to the groundwater.

A small portion of the north production area and the old sanitary land fill east of McCoy Road were known to be contaminated by DDT. Containment plans were generated by the PBA in April, 1975, and the USAEHA examined this plan and performed on-site inspections and tests during 28-31 July 1975. Based on these actions, a detailed containment program was recommended (USAEHA, 1976). A test boring in the north production area encountered a shallow water table and chemical analyses of soil samples revealed substantial DDT contamination. Based on these results, a monitoring system was recommended for the area which was to monitor four depths at six sites, but the system was never implemented. Figure 3 presents the lithologic log, DDT concentrations, permeabilities, and water table measurements from this report. The old landfill site was covered with a low permeability (7.41×10^{-7} cms) silt cap, and an impinging waterway was rerouted. No groundwater monitoring efforts were planned in this area, but continued evaluation of downstream surface waters was recommended. Surface sample sites are shown on Figure 2.

The U. S. Army Engineer Waterways Experiment Station (WES) performed a study to collect and review all data applicable to determine the potential of groundwater contamination (Broughton, Jerald D., 1977). Data generated by the U. S. Army Engineer Districts (Fort Worth, Little Rock, and Vicksburg), the PBA, the U. S. Geological Survey, the U. S. Soil Conservation Service, and the Arkansas Geological Commission were analyzed and the study concluded that the potential for groundwater contamination was present at PBA and a proposal to conduct a hydrogeological study to determine the extent of contamination was submitted to PBA as a part of the results of the literature study.

Depth, ft	Sample Location	Lithology	DDT Concentration	Permeability
0	o o	Black like fly ash w white nodules.	353,000 ppm	
	o	Stiff, yellow, sandy, silty clay.	303,000 ppm	
5	o o	Yellow, grey, sandy, silty clay w red nodules which may be pieces of brick. Easily molded by hand.	7,350 ppm 911 ppm 1,180 ppm	
	o o	Soft, grey clay with red. Mettling makes ribbon easily.	8,790 ppm	6.9×10^{-8} cms
10	o	▽ Water level 4 hrs after drilling Buff clay or silt layered with limonite. Hard in sampler, soft on auger.	606 ppm	
15	o o □	Hard, bluff clay with limonite layers. ▽ Water level 1 hr after drilling	250 ppm ND	2.7×10^{-7} cms
20	o	Med, hard, dark grey, fine sand.	ND	
	o	Dark grey-green sand with layers of peat; crumbly.	ND	
25 30	□	Med grey sandy clay with thin bands of peat.	12.2 ppm	8.1×10^{-6} cms

o Jar Sample

□ Tube Sample

▽ Water Level

Figure 3. DDT Containment Program Boring

Purpose and Scope

The purpose of this study was to support the PBA efforts to determine if contaminants had reached the groundwater and if so, were they approaching the installation boundary or migrating off post. This determination required that the groundwater regime be identified in all geologic units to define the hydrogeologic characteristics of the aquifer(s).

The exploration and sampling were concentrated along PBA's boundaries and in proximity to known contaminated sources and included subsurface exploration, monitoring well installation, and physical tests on the soil samples.

The chemical evaluation of soil and water samples was conducted by the PBA and these results are not presented in this report.

PART II: PHYSICAL SETTING AND CLIMATE

Landforms

PBA is situated on three landforms (1) floodplain of the Arkansas River, (2) an alluvial terrace, and (3) tertiary uplands. The local relief of the terrace is less than 20 ft, except along a few streams that have cut deeper than 20 ft. A 30- to 50-ft-high north-south trending bluff separates the floodplain from the terraces. Total relief on PBA is 150 ft from an elevation of 190 ft msl at the Arkansas River to an elevation of 340 ft msl in the northwestern portion (USAEHA, 1974). Plate 1 is a topographic map of PBA.

Geology

The PBA is within the Mississippi embayment, a 100,000 sq mi, wedgeshaped portion of the Gulf Coastal Plain extending from its apex in southern Illinois to the Gulf of Mexico. The embayment is a southerly plunging syncline which is filled with sedimentary rocks and sediment ranging in age from Jurassic to Quaternary and reaching a maximum thickness of about 18,000 ft in the southern part of the region. The PBA is on the western flank of the embayment where approximately 4,000 ft of sediments overlie the Paleozoic bedrock. The Cretaceous system occupies the lower 3,000 ft and is overlain by about 1,000 ft of the Tertiary system which is important to the Hydrogeologic Survey of PBA. The Tertiary interval includes the Sparta Sand, an artesian aquifer which is a major source of water in the region. This aquifer is separated from the locally developed shallow aquifers in the terrace and alluvium by substantial thickness of low-permeability clay deposits. The majority of the clays are in the Jackson Formation which is not a source of water for the region (Cushing, E. M.; Boswell, E. H.; and Hosman, R. L., 1969). Figure 4 is a generalized stratigraphic column derived from

ERA	SYSTEM	SERIES	GROUP	FORMATION
Cenozoic	Quaternary	Holocene	Alluvium	Alluvium
		Pleistocene	Quaternary Terrace	Undifferentiated
	Tertiary	Eocene	Jackson	Undifferentiated
			Claiborne	Cockfield Cook Mountain Sparta Sand Cane River Carrizo Sand
			Wilcox	Undifferentiated
		Paleocene	Midway	Porters Creek Clayton
Mesozoic	Cretaceous	Gulf	Navarro	Arkadelphia Nacatoch
			Taylor	Saratoga Marlbrook Annona Ozan
			Austin	Basal Detrital Unit Pre-Ozan
Paleo-zoic	Cambrian through Pennsylvanian			
	Pre-Cambrian			

Figure 4. Generalized Stratigraphic Column for PBA

VTN (1975) and credited to Caplan, W. M. (1945) and Dunbar, C. O. and Wagge, K. M. (1969).

Quaternary deposits (meander belt deposits, alluvium, and terraces) dominate PBA except for the northwestern sector of the PBA which is blanketed by the older Tertiary age Jackson Group (Plate 2). The surface of the alluvium and meander belt deposits are primarily coarse grained, while the terrace and Jackson surfaces are composed of fine-grained soils (silts and clays).

Meander Belt Deposits

Meander belt deposits are developed within a floodplain during overbank flow and channel migration. At PBA the Arkansas River floodplain includes all lands between the Arkansas River and the escarpment bordering the Pleistocene Terrace--more specifically, those lands lying between the old channel which flowed through Yellow Lake and the Arkansas River. Meander belt deposits are alluvial in origin and include point bar deposits (ridges and swales) composed of alternating arcuate bands of the coarse-grained ridges and fine-grained swales, abandoned channels which are composed of fine-grained soil and natural levee deposits generally composed of silty sands and silts. The meander belt deposits at PBA are primarily poorly graded sand and some highly plastic clays. The sands are between Yellow Lake and the Arkansas River, and the clay deposits are concentrated along the old river channel and west to Yellow Bluff. Backswamp deposits are another environment of deposition within floodplains. These deposits are predominantly clay with varying amounts of organic material and occur between meander belts or meander belts and valley walls (escarpments). Backswamp deposits probably occur within the floodplain of the Arkansas River in PBA but have not been identified because a more detailed study would be required to depict them. For this study, if backswamp deposits occur, they are included in the meander belt deposits.

Recent Alluvium

Recent alluvium are those deposits laid down during comparatively recent geologic time by a stream or other body of running water as a sorted or semisorted sediment in the bed of the stream or on its floodplain. The deposits can range from unconsolidated detrital material to clay. The alluvium depicted on Plate 2 is primarily silt and clay in the tributaries of the Arkansas River. The fine-grained nature of the source of these deposits is due to the source materials and the relatively low carrying capacity of the small streams at PBA.

Pleistocene Terrace

The Pleistocene terrace deposits occupy that portion of the PBA lying between the Jackson surface and the meander belt or alluvial deposits. The terrace is the result of rising and lowering of sea level during Pleistocene time. During a low still stand of the sea, the Jackson surface was eroded to an elevation approximating 100 ft in the vicinity of Pine Bluff by the ancient Arkansas River system. With the subsequent rise in sea level, an ancient Arkansas River deposited a thick sequence of gravels, sands, and silts, sandy silts or clays, in that order. This deposition stage was followed by a lowering of sea level which subjected this surface to erosion and subsequent reentrenchment of the Arkansas River to its current position. Cook (1966) named this surface the Hazlehurst Terrace from the type location in Hazlehurst, Georgia, and established elevation limits of 215 to 275 ft. These elevations correlate with the terrace at the PBA.

Soils

Surface soils at PBA range from clays, silts, silty sands to sands depending upon the environment of deposition. All of these soils may be encountered in the subsurface although the predominant soils are silts, sandy silts, and clays. The U. S. Department of Agriculture has mapped five soil associations on PBA. The Angie-Sacul (Saffel)-Savannah association, located on the northern end of PBA, is deep, moderately well drained, slowly and moderately slowly permeable, acid, and loamy soils. This soil association consists of the following series: 35 percent

Angie, 25 percent Sacul, 25 percent Savannah, and 15 percent inclusions of Amy, Ochlockonee, Iuka, Myatt, Cahaba, Susquehanna, and Pheba. Angie soils are a grayish-brown fine sandy loam surface soil overlying a yellowish-brown silty clay loam upper subsoil. Sacul soils consist of a grayish-brown fine sandy loam surface soil over yellowish-red or red clay subsoil that is mottled gray in the lower part. Savannah soils are a grayish-brown fine sandy loam surface soil over a yellowish-brown loam or sandy clay loam subsoil that has a gray, yellow, and brown mottled fragipan in the lower part.

The Cahaba-Savannah soil association occupies a small niche on the western boundary of PBA. This association is deep, well and moderately well drained, moderately and moderately slowly permeable, acid, and loamy and consists of the following soil series: 45 percent Cahaba, 40 percent Savannah, and 15 percent inclusions of Angie, Amy, Pheba, and Sacul. The well-drained Cahaba soils are grayish-brown or brown fine sandy loam surface soil over yellowish-red or red sandy loam or sandy clay loam subsoil. The moderately well-drained Savannah soils were described in the previous paragraph.

The Amy-Pheba-Savannah soil association occupies the central part of the Arsenal. These soils are deep, poorly to moderately well drained, slowly and moderately slowly permeable, acid, and loamy. This association consists of the following soil series: 45 percent Amy, 25 percent Pheba, 20 percent Savannah, and 10 percent inclusions of Myatt, Cahaba, Angie, Sacul, and Ochlackonee. The poorly drained Amy soils are gray silt loam surface soil over gray, mottled silt loam or silty clay loam subsoil. The somewhat poorly drained Pheba soils are dark gray to grayish-brown silt loam or loam subsoil with a fragipan in the lower part.

The Henry-Calloway-Grenada soil association occurs on the southern end of PBA. These soils are deep, poorly to moderately well drained, slowly permeable, level to gently sloping, acid, and loamy. This association is made up of the following soil series: 40 percent Henry, 40 percent

Calloway, 15 percent Grenada, and 5 percent inclusions of Falaya and Zachary soils, and gullied land. The poorly drained Henry soils are grayish-brown or gray silt loam surface soil over gray, mottled silt loam or silty clay subsoil that has a fragipan. The somewhat poorly drained Calloway soils are grayish-brown silt loam or silty clay loam subsoil with a fragipan. The moderately well drained Grenada soils are brown silt loam or silty clay loam upper subsoil and mottled gray and yellowish-brown lower subsoil that is a fragipan.

The Crevasse-Portland soil association occupies an area around Yellow Lake and a narrow strip running north along the east edge of the Arsenal. These soils are deep, somewhat poorly drained, rapidly to very slowly permeable, and acid to neutral in pH. The sandy and clayey bottom land soils are subject to frequent flooding. The association consists of the following soil series: 45 percent Crevasse, 30 percent Portland, and 25 percent inclusions of Rilla, Keo, Morgenfield, Latanier, Desha, and Perry. The excessively drained Crevasse soils are brown loamy sand surface soil overlying light yellowish-brown sand. The somewhat poorly drained Portland soils are dark grayish-brown silty clay loam to clay surface soil over dark brown to red, mottled clay subsoil.

Figure 5 is a generalization of the soil association distribution (Chemical Systems Laboratory, 1979). The U. S. Department of Agriculture divides soils into horizons. These horizons are identified as A, B, C, and D, which are defined as zones of humus accumulation and mineral leaching, mineral accumulation, unconsolidated or slightly altered parent material, and unaltered parent material, respectively. Plate 3 is a conversion of the USDA soil types (A horizon) to classification according to the Unified Soil Classification System (USCS).

Groundwater

The PBA is underlain by two aquifers that are widely used as a water supply. These aquifers are the Quaternary sands and gravels of

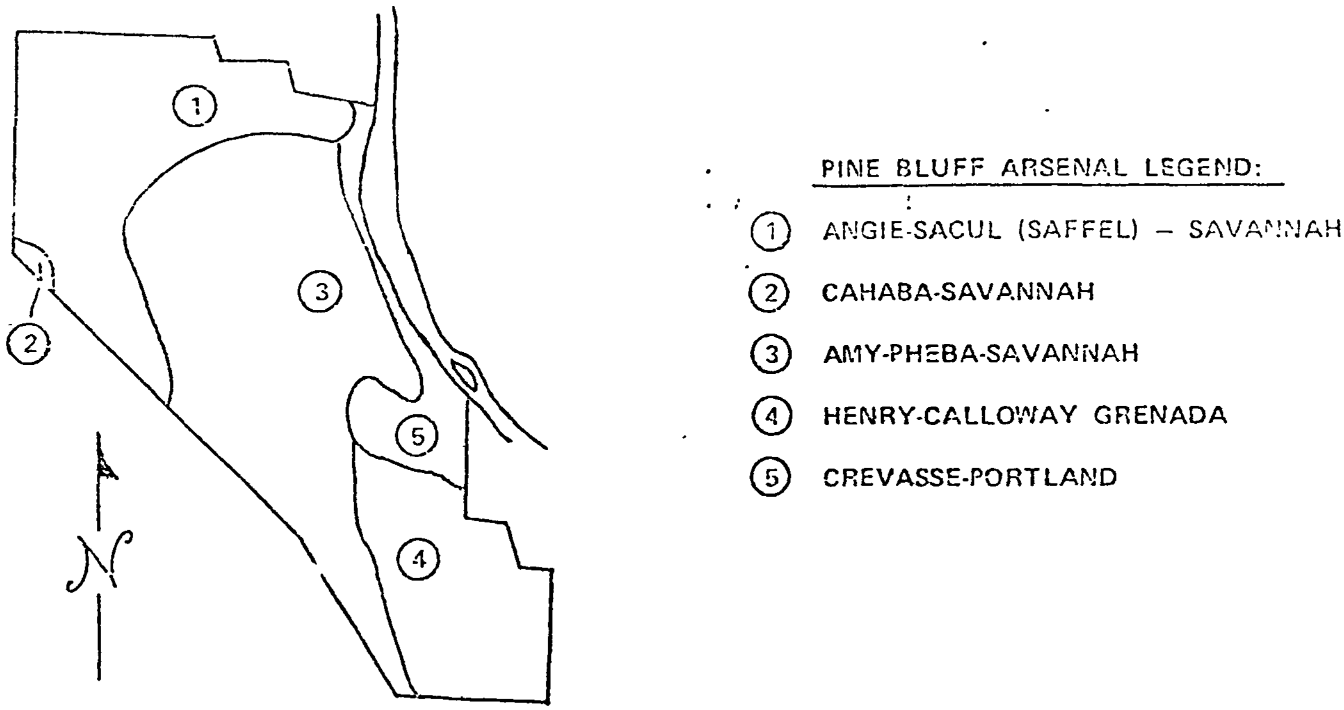


Figure 5. Soil associations at Pine Bluff Aresnal

the alluvium and terrace and the deeper Tertiary Sparta sand. The Quaternary aquifer is shallow (usually less than 50 ft deep) and is used in the surrounding areas for individual residence consumption, farm irrigation, and fish farming. Recharge is primarily by infiltration but along some reaches of the Arkansas River, the river is effluent to the aquifer. The PBA does not use this aquifer.

The Sparta sand is at depths of 800-1000 ft in the Pine Bluff area including PBA and ranges in thickness between 450-800 ft. The potentiometric surface occurs at depths of 200-250 ft (AEHA, 1974). The top of the Sparta sand lies at elevations ranging from 0 msl in the northwestern portion of Jefferson County to 900 ft below msl in the southeastern portion of the county. Wells in the Sparta produce some 50 million gallons per day for industry and municipal water supplies. Recharge is by infiltration in the outcrop area west of Jefferson County and by infiltration from the overlying Quaternary deposits north and southeast of Jefferson County (VTN, 1975). The Sparta sand is not hydraulically connected to the Quaternary aquifer at the PBA.

All of the Eocene (see Figure 4) formations below the Jackson Group have aquifers associated with them but the water demands of the Pine Bluff area have not required that these deeper formations be exploited. The remainder of the Tertiary (Paleocene) and all of the Cretaceous have no substantial aquifers and only occassionally does a formation have members which yield large quantities of water. Excessive mineralization also precludes using these deeper aquifers (Cushing, E. M., Boswell, E. H., and Hosman, R. L., 1964).

Climate

The PBA has temperatures ranging from a normal average low temperature of 44.2°F in January to a normal average high temperature of 83.2°F in July. The smooth transition from these extremes results in an average annual temperature of 64.2°F (VTN, 1975).

Approximately 50 in. of rainfall are spread over 100 days of measurable precipitation. This precipitation is scattered throughout the year with monthly averages ranging from 3.5 in. during the fall to 4-5 in. during winter and spring. Snowfall is usually limited to 1-2 in. per year with many winters recording none. The potential evaporation, as measured with evaporation pans, is 58 in. per/year (VTN, 1975).

PART III: DATA COLLECTION

Field Exploration

The WES initiated a field drilling and sampling program in February 1977 as the initial phase of the hydrogeological study and completed the major portion of the sampling program in August 1977. A total of 108 borings were drilled during this phase. An additional four borings were drilled and sampled during November 1978 to approximate the total thickness and characteristics of the water bearing strata in the Pleistocene terrace. The purpose of the field exploration was to obtain soil samples for physical and chemical analysis and to collect water samples for chemical analysis. The PBA initiated, prepared, and monitored safety standard operating procedures and furnished all equipment and facilities as required during the drilling and sampling program. Plate 4 shows the boring locations of this program and the location of selected cross sections.

Sampling Procedures

Undisturbed and disturbed soil samples were acquired during the sampling program using a Mobil B-50 drill rig. All of the shallow borings were drilled using the hollow-stem auger technique. The deep borings (last four) were drilled with a Failing 1500 drill rig, and mud was used to preclude hole caving. An undisturbed sample is defined as a sample of minimal disturbance suitable for laboratory test. Undisturbed samples were obtained by pushing a thin-walled, 3-in.-diam, fixed piston sampler (Hvorslev) (see Figure 6) into the stratum being sampled. A 75 cm sample was retrieved from its position and the sample (Shelby) tube removed from the Hvorslev sampler head. The bottom of the tubed sample was examined to field classify the soil type and consistency, qualitatively describe the water content, and color according to the data management users guide (U. S. Army Chemical Systems Laboratory, 1977). The tube was then placed in an extruder and the upper 10-20 cm

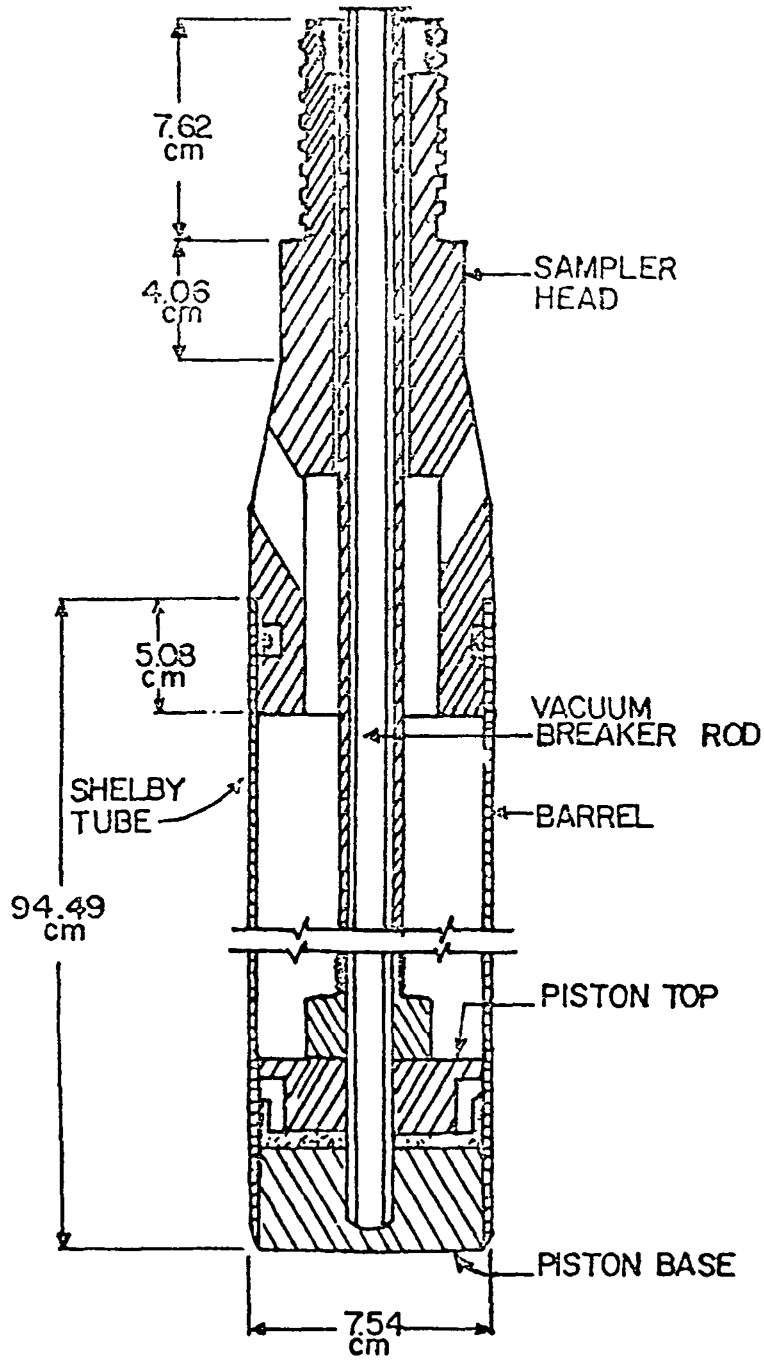


Figure 6. Sketch of Hvorslev Sampler

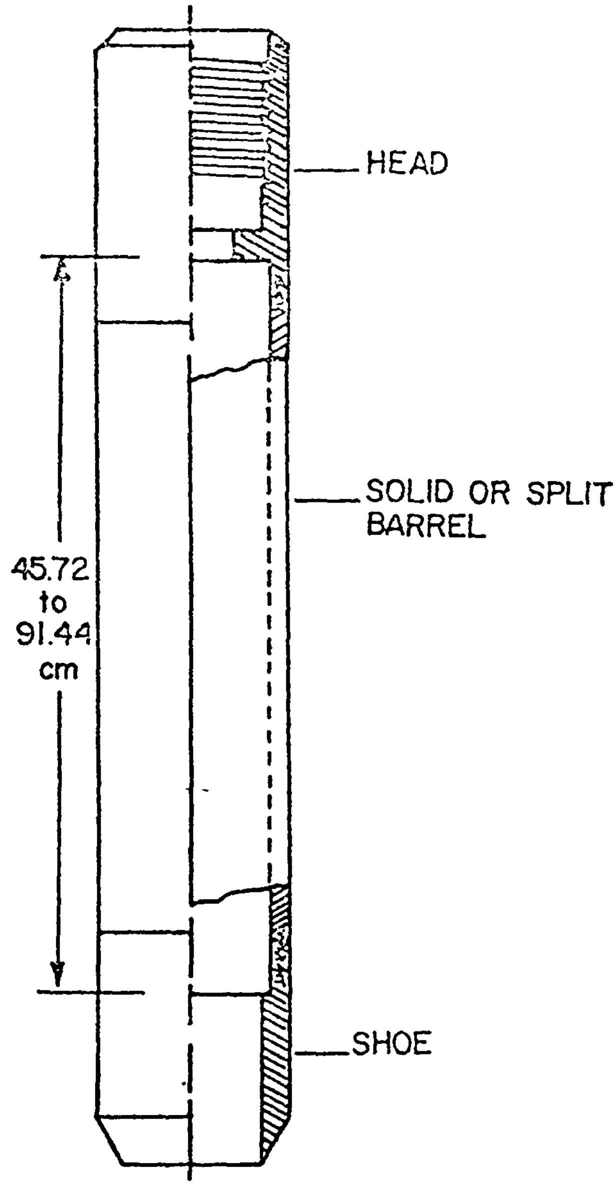
(amount was dependent on the total sample recovery, but in no case was a physical test specimen retained without a matching chemical test specimen) pushed out of the tube. The extruded portion was trimmed to remove any contaminant introduced by the sampling apparatus, examined to ascertain physical description, placed in a jar, and labeled for subsequent delivery to the PBA testing laboratory for chemical tests. Packers were inserted in each end of the sample tube and the tube labeled for storage at PBA for subsequent shipment to the WES for physical testing.

Disturbed soil samples were obtained with a 1.375-in. split-spoon sampler (see Figure 7) driven into the stratum being sampled by a 140-lb hammer with a 30-in. drop. A disturbed sample contains all the constituents of a particular stratum, but the original soil structure has been altered. These disturbed samples are sufficient for classification (Atterberg limits and sieve and hydrometer analysis), water content analysis, and chemical analysis.

Sampling Frequency

The sampling plan called for seven soil samples and one water sample to be taken at each boring location. The vertical distribution of the soil samples is shown in Figure 8. The position of the upper three samples was not varied from site to site but the lower four samples varied according to the estimated water table elevation. Sample 6 was positioned at the estimated water table, sample 7 three meters (m) below the water table, and samples 4 and 5 were evenly distributed between samples 3 and 6. Where the elevation of the water table was underestimated, additional sample(s) were required and the vertical spacing was dependent on a revised on-site estimate of the water table. Usually a conservative estimate (high elevation) was made to preclude drilling past this sampling point and in no case was the sampling interval increased. On several occasions this method necessitated more than one additional sample.

Where the water table elevation was over estimated which was indicated by an increase in water content in sample 4 or 5, the next sampling interval was shortened to try and intersect the water table.



O.D. 5.08cm, 6.35cm, 7.62cm, or 8.89cm
I.D. 3.81cm, 5.08cm, 6.35cm, or 7.62cm

Figure 7. Sketch of split spoon sampler.

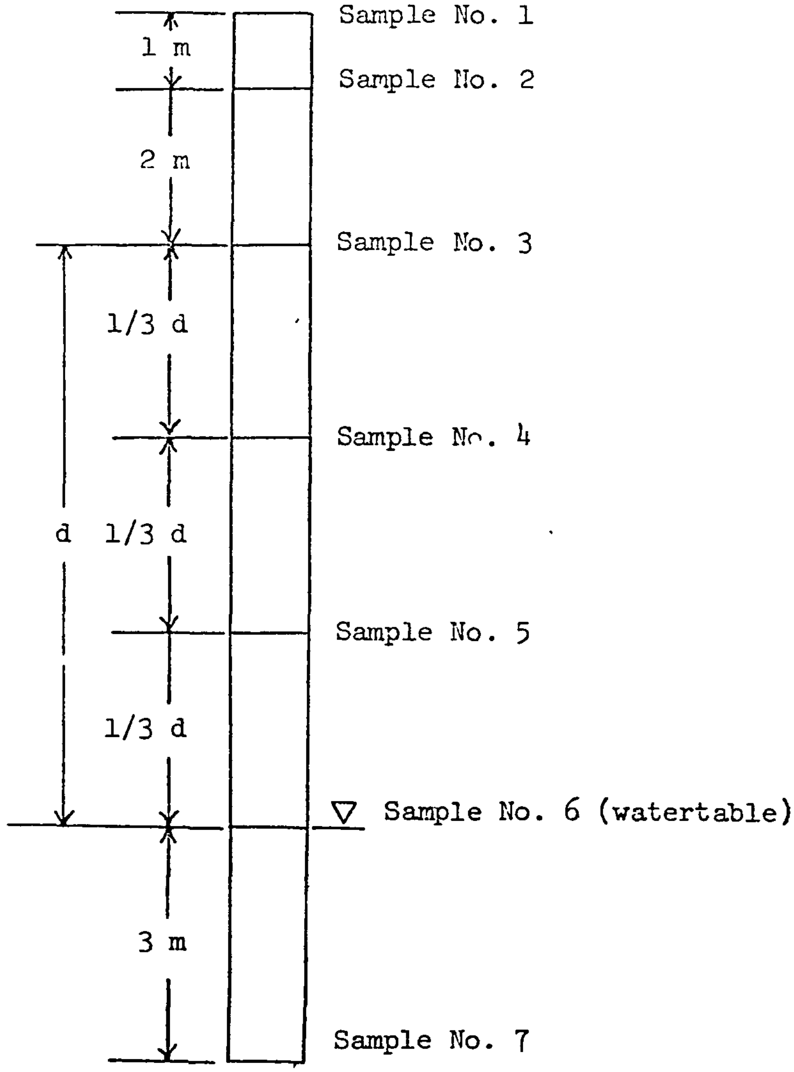


Figure 8. Vertical distribution of soil samples

Where the over estimation was discovered by saturated drill cuttings, drilling was halted and a sample was taken. The next sample was then taken 3 m below the water table.

Where the water table was estimated less than 6 m deep, a sampling interval of 1-1.5 m as assigned and the positions of samples 3-7 calculated accordingly. With extremely shallow water tables, fewer than seven samples were often obtained.

Immediately after obtaining the soil sample at groundwater intersection, a groundwater sample was obtained with a 2.54 cm, plastic bailer with a stainless steel foot valve. Figure 9 is a sketch of the bailer.

Sample Distribution

The soil samples were transported daily to a heated storage building and stacked to await shipment to WES. After the chemical scans were run by PBA and no hazardous or toxic materials were identified in the samples, the undisturbed samples were placed in specially constructed racks and transported to WES. The racks were cushioned to prevent shock and the sample tubes were pinned to prevent rotation and sample disturbance. The disturbed samples were transported in a manner to prevent breakage of the glass jars. When the samples arrived at WES they were stored with proper orientation in a controlled environment to await physical testing.

The soil samples for chemical scans were sealed in glass jars, labeled, and transported to controlled environment storage to await the tests. Water samples were placed in jars, labeled, and subsequently transported to the PBA testing facilities. Deviation from the above procedures were required with samples from sites that had a potential for white phosphorous contamination. In these cases the water samples were treated with a preservative and the water and soil samples were immediately transported to the testing facility at PBA.

Well Installation

After the last soil or water sample had been extracted at each boring location, the depth to the water table was determined for

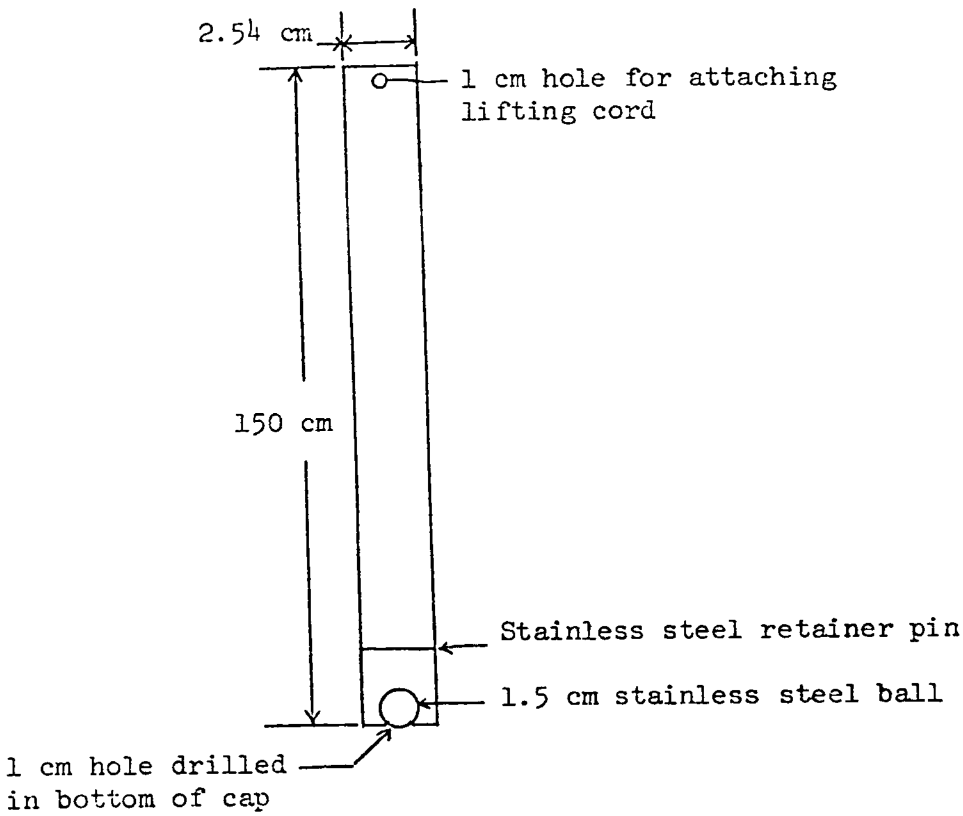


Figure 9. Section through bailer

placement of a monitoring well. In coarse-grained material the water table could usually be measured without any time lapse, but in fine-grained materials it was necessary to estimate the water level from the water content of the soil. After the depth of a monitoring well was determined, a well string was made up which consisted of (from bottom to top) an approximate 1.5 m section of capped, solid polyvinal chloride (PVC) pipe, an approximate 1.5 m section of slotted PVC pipe, and a length of solid PVC pipe sufficient to rise approximately 1 m above the ground surface. Figure 10 shows a typical well installation. All joints were sealed to prevent any leakage above the screen. A 1 cm vent hole was drilled through the PVC approximately 10 cm below the top to permit equalization of pressures. A slip-on PVC cap was placed over the top of the well string.

The made-up well string was placed through the hollow-stem auger so the top of the well screen was at the water table. The hollow stem auger served as a casing to prevent collapse of the boring below the water table. When the well string was in place, the hollow-stem auger was removed. The riser (length of PVC pipe above the ground surface) was checked and adjusted if slippage either up or down had occurred. The annulus between the well string and boring wall was filled with washed river sand to a level approximately 1.5 m above the top of the screen. The remaining annulus was grouted using a water, cement, and bentonite grout (Figure 10). The bentonite was added to prevent shrinkage and cracking during the curing process. Voids caused by settlement of the grout were subsequently filled with a similar grout mixture. Each observation well was labeled and the bailer was suspended on the inside of each well. Appendix A contains measurements made for the stickup (STKUP), screen (SCREN), sand filter (SFILT), and grout (GROUT).

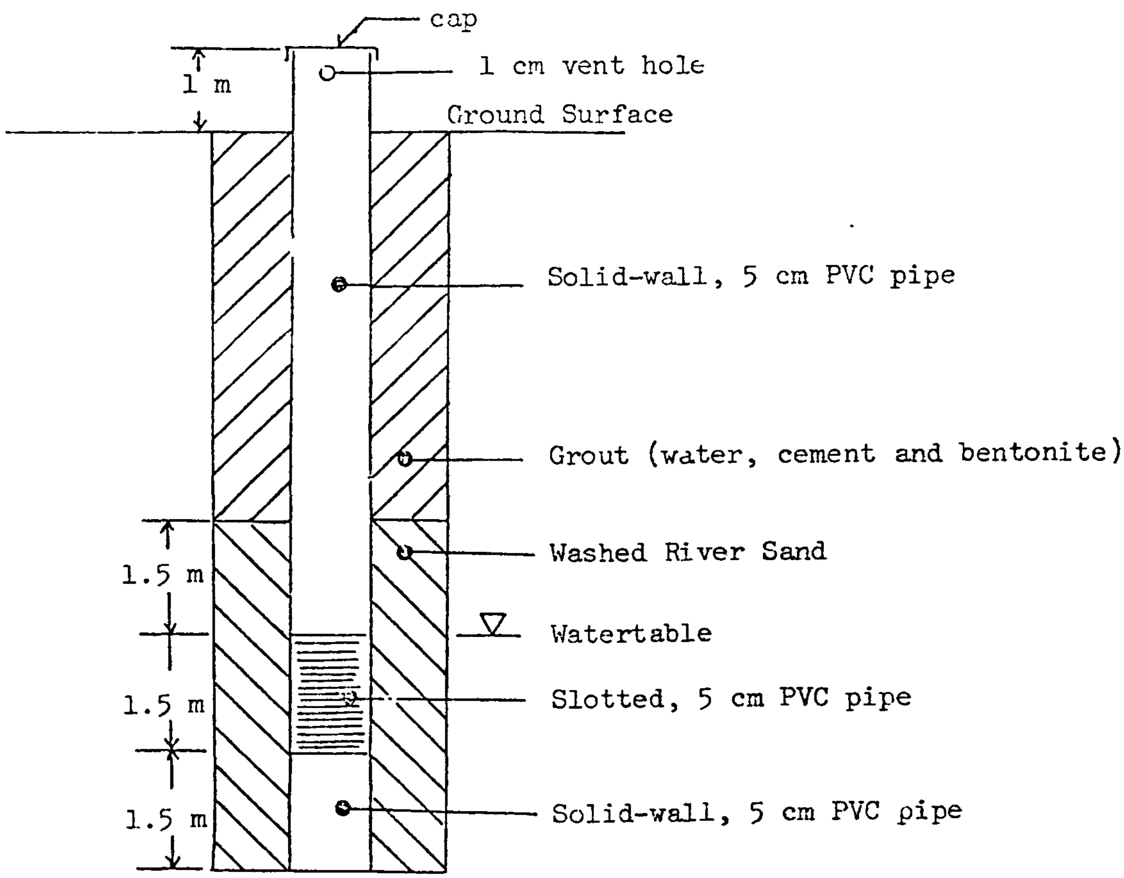


Figure 10. Section through typical well installation

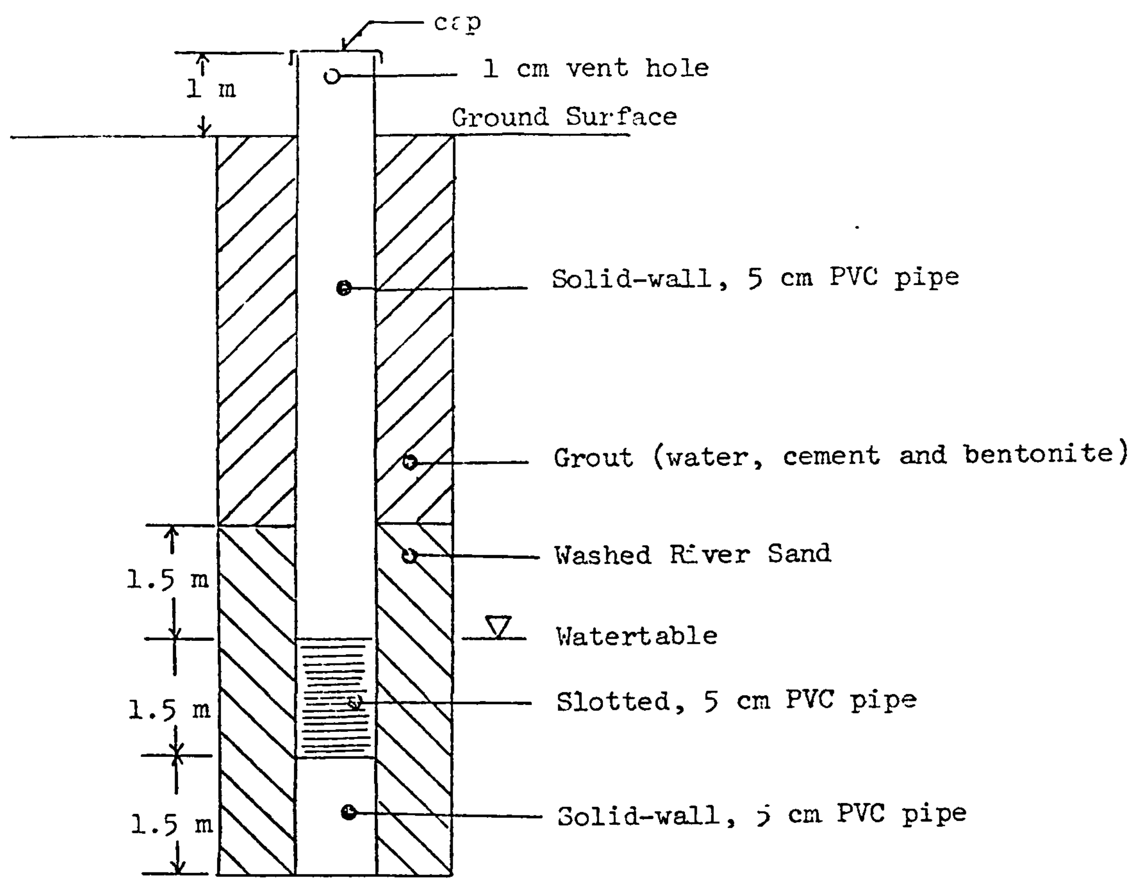


Figure 10. Section through typical well installation

Physical Test

Standard soil test procedures as specified by Engineer Manual 1110-2-1906, "Laboratory Soil Testing," were followed during testing. Classification tests (Atterberg limits and grain-size distribution of the soils) were performed on all samples; water content and density tests were performed on selected samples; and permeability tests were usually performed on two samples per boring, one above and one below the water table. Detailed testing procedures are presented in Appendix B.

Classification of soils was made according to the USCS which depends upon grain-size distribution and the Atterberg limits. Grain-size distribution was determined with standard sieves and a hydrometer and the Atterberg limits (liquid and plastic limits) were determined with standard devices. The liquid and plastic limits are the water contents at the boundaries between the semiliquid and plastic state and the plastic and semisolid state, respectively. Figure 11 shows the USCS by which the PBA soil samples were described.

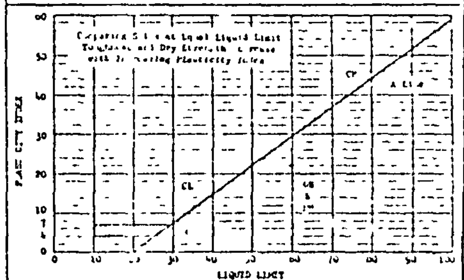
Water content (the amount of free water in a soil) and soil density (the weight per unit volume) are important engineering relationships and are useful correlations among samples for which a full suite of physical test data are not available.

Permeability is a measure of the soils ability to transmit water. Permeability tests were usually performed on two representative samples per boring which allowed meaningful correlations to be made among the various USCS types and general evaluation of the hydrogeological conditions of the PBA. The specimen above the water table was believed to be from the least permeable stratum between the surface and the water table. This material should furnish the most resistance to the downward migration of contaminants. The specimen below the water table was selected to furnish an approximation of the maximum rate of horizontal migration of contaminants.

UNIFIED SOIL CLASSIFICATION
(Including Identification and Description)

Major Divisions		Group Symbols	Typical Names	Field Identification Procedures (Excluding particles larger than 3 in. and basing fractions on estimated weights)			Information Required for Describing Soils	Laboratory Classification Criteria
1	2	3	4	5			6	7
Coarse-grained Soils: More than half of material is larger than No. 200 sieve size. (The No. 200 sieve size is about the smallest particle visible to the naked eye)	Gravels: More than half of coarse fraction is larger than No. 4 sieve size (For visual classification, the 1/4 in. size may be used as equivalent to the No. 4 sieve size). Clean Gravels (little or no fines)	GW	Well graded gravels, gravel sand mixtures, little or no fines	Wide range in grain sizes and substantial amounts of all intermediate particle sizes			For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions, and drainage characteristics	$C_u = \frac{D_{60}}{D_{10}}$ Greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
		GP	Poorly graded gravels or gravel sand mixtures, little or no fines	Predominantly one size or a range of sizes with some intermediate sizes missing				Not meeting all gradation requirements for GW
	Gravels with Fines (Appreciable amount of fines)	GM	Silty gravels, gravel-sand silt mixture	Nonplastic fines or fines with low plasticity (for identification procedures see ML below)			Give typical name; indicate approximate percentages of sand and gravel, maximum size, angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbol in parentheses	Atterberg limits below "A" line or PI less than 4 — Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols
		GC	Clayey gravels, gravel sand-clay mixtures	Plastic fines (for identification procedures see CL below).				Atterberg limits above "A" line with PI greater than 7
	Sands: More than half of coarse fraction is smaller than No. 4 sieve size. Clean Sands (little or no fines)	SW	Well graded sands, gravelly sands, little or no fines	Wide range in grain size and substantial amounts of all intermediate particle sizes				$C_u = \frac{D_{60}}{D_{10}}$ Greater than 6; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
		SP	Poorly graded sands or gravelly sands, little or no fines	Predominantly one size or a range of sizes with some intermediate sizes missing			Example: Silty sand, gravelly, about 20% hard, angular gravel particles 1/2 in. maximum size; rounded and subangular sand grains, coarse to fine; about 15% nonplastic fines with low dry strength; well compacted and moist in place; alluvial sand; (SM)	Not meeting all gradation requirements for SW
	Sands with Fines (Appreciable amount of fines)	SM	Silty sands, sand-silt mixtures	Nonplastic fines or fines with low plasticity (for identification procedures see ML below)				Atterberg limits below "A" line or PI less than 4 — Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols
		SC	Clayey sands, sand-clay mixtures.	Plastic fines (for identification procedures see CL below)				Atterberg limits above "A" line with PI greater than 7
				Identification Procedures on Fraction Smaller than No. 40 Sieve Size				
				Dry Strength (Crushing characteristics)	Dilatancy (Reaction to shaking)	Toughness (Consistency near PL)		
Fine-grained Soils: More than half of material is smaller than No. 200 sieve size.	Silts and Clays: Liquid limit is less than 50	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity	None to slight	Quick to slow	None	For undisturbed soils add information on structure, stratification, consistency in undisturbed and remolded states, moisture and drainage conditions	
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	Medium to high	None to very slow	Medium		
		OL	Organic silts and organic silty clays of low plasticity	Slight to medium	Slow	Slight	Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains, color in wet condition, odor if any, local or geologic name and other pertinent descriptive information, and symbol in parentheses	
	Silts and Clays: Liquid limit is greater than 50	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	Slight to medium	Slow to none	Slight to medium		
		CH	Inorganic clays of high plasticity, fat clays	High to very high	None	High		
		OH	Organic clays of medium to high plasticity, organic silts	Medium to high	None to very slow	Slight to medium	Example: Clayey silt, brown, slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (ML)	
Highly Organic Soils		Pt	Peat and other highly organic soils	Readily identified by color, odor, spongy feel and frequently by fibrous texture				

Use grain-size curve in identifying the fractions as given under field identification. Determine percentages of gravel and sand from grain size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size) coarse grained soils are classified as follows: Less than 5%: GW, GP, SW, SP; More than 12%: GM, GC, SM, SC; 5% to 12%: Borderline cases requiring use of dual symbols



PLASTICITY CHART
For laboratory classification of fine-grained soils

(1) Boundary classifications. Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, well graded gravel-sand mixture with clay binder. (2) All sieve sizes on this chart are U. S. standard.

FIELD IDENTIFICATION PROCEDURES FOR FINE-GRAINED SOILS OR FRACTIONS
These procedures are to be performed on the minus No. 40 sieve size particles, approximately 1/64 in. For field classification purposes, screening is not intended, simply remove by hand the coarse particles that interfere with the tests.

Dilatancy (reaction to shaking)

After removing particles larger than No. 40 sieve size, prepare a pat of moist soil with a volume of about one-half cubic inch. Add enough water if necessary to make the soil soft but not sticky.
Place the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the pat stiffens, and finally it cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil.
Very fine clean sands give the quickest and most distinct reaction whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour, show a moderately quick reaction.

Dry Strength (crushing characteristics)

After removing particles larger than No. 40 sieve size, mold a pat of soil to the consistency of putty, adding water if necessary. Allow the pat to dry completely by oven, sun, or air drying, and then test its strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.
High dry strength is characteristic for clays of the CH group. A typical inorganic silt possesses only very slight dry strength. Silty fine sands and silts have about the same slight dry strength, but can be distinguished by the feel when powdering the dried specimen. Fine sand feels gritty whereas a typical silt has the smooth feel of flour.

Toughness (consistency near plastic limit)

After particles larger than the No. 40 sieve size are removed, a specimen of soil about one-half inch cube in size, is molded to the consistency of putty. If too dry, water must be added and if sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about one-eighth inch in diameter. The thread is then folded and rerolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached.
After the thread crumbles, the pieces should be lumped together and a slight kneading action continued until the lump crumbles.
The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at the plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as kaolin-type clays and organic clays which occur below the A-line.
Highly organic clays have a very weak and spongy feel at the plastic limit.

Adopted by Corps of Engineers and Bureau of Reclamation, January 1952

Figure 11. Unified Soil Classification System

PART IV: STUDY RESULTS

Soil Characteristics

Classification

Of the 782 samples tested, the fine-grained material predominates with 572 samples being classified as silt and clay (Figure 11). The clays are further subdivided into two groups, L and H, according to the liquid limits of the material. In these groups the symbol C stands for clay, with L and H denoting low or high liquid limits, with the dividing line set at a liquid limit of 50. The soils are primarily inorganic clays. Low plasticity clays are classified as CL and are usually lean, sandy, or silty clays. The medium and high plasticity clays are classified as CH; these include the fat clays, gumbo clays, and some volcanic clays. Three hundred and twenty-four samples were classified CL and 132 samples were classified as CH.

The silts are also further subdivided into two groups according to the liquid limits of the material (Figure 11). In these groups the symbol M has been used to designate predominantly silty materials. The symbols L and H represent low and high liquid limits, respectively, and dividing line between the two is set at a liquid limit of 50. The soils in the ML and MH groups are sandy, clayey, or inorganic silts with relatively low plasticity including loess-type soils and rock flours. Seventy-two of the samples were classified as ML and nine of the samples were classified as MH.

Soils with liquid limits and plasticity indexes falling within the hachured zone of the classification chart are assigned a dual classification, CL-ML; 35 of the samples classified were within this zone (Figure 11).

The coarse-grained material was dominated by silty sands (SM). This classification covers sands with between 12 and 50 percent of the sample passing the No. 200 sieve (smaller than .074 mm) and the plasticity index and liquid limit of the materials passing the No. 40 sieve (smaller than 0.42 mm) plot below the "A" line on the plasticity chart (Figure 11). One hundred and two samples were classified as SM.

Forty-five samples were classified as poorly graded sands which contain little or no plastic fines (less than 5 percent passing the No. 200 sieve). This material, SP, is called poorly graded because the sand grains fall within a narrow size range.

Fifty-three samples were classified as borderline cases between the SP and SM and received a designation of SP-SM. This group has between 5 and 12 percent of the material passing the No. 200 sieve.

Nine samples were classified as clayey sand (SC). This is a sandy soil with between 12 and 50 percent fairly high plasticity material passing the No. 200 sieve. The liquid limit and plasticity index plot above the "A" line on the plasticity chart (Figure 11).

One sample received dual classification of SC-SM. This material has between 12 and 50 percent passing the No. 200 sieve and the liquid limits and plastic limit of the sample plots within the hachured area of the classification (Figure 11).

The predominance of fine-grained material is attributed to the majority of the samples being obtained within the fine-grained upper strata of the terrace material and the finer grained material in the Jackson undifferentiated.

The liquid limits of the fine-grained material ranged from 21 to 87 percent water with the 25-35 percent water range predominating. The plastic limits of the fine-grained material ranged from 10 to 34 percent water with the 15-20 percent water range predominating. Plates 5-10 are cross sections along selected traverses (Plate 4) and the soil types are based on the physical analyses of the soil samples.

Water Content and Density

Water contents ranged from 2.9 to 40.6 percent with 15 to 25 percent occurring most often. The accompanying densities ranged from 1.21 to 1.45 grams per cubic centimetre (g/cc) with the range of 1.4 g/cc to 1.7 g/cc being predominant.

Permeability

The permeabilities ranged from 0.0 cm/sec to 2.0 cm/sec. The majority of the coarse-grained materials (SP, SP-SM, SM, SC, and SC-SM) exhibited permeabilities in the range of 1×10^{-3} to 1×10^{-5} cm/sec. The fine-grained materials (ML, MH, CL-ML, CL, and CH) usually exhibited permeabilities in the range of 1×10^{-5} to 1×10^{-8} cm/sec. Permeability distribution according to the USCS types is shown in Table 3.

Figures 12 and 13 show the distribution within soil types for the coarse-grained and fine-grained soils, respectively. Table 4 presents the results of all physical tests.

Water Levels

Water level measurements were made on a number of occasions but only one complete round was made with the specific purpose of obtaining a set within a short time frame. This set of measurements was made during 2-4 August 1977 and these elevations are shown in Table 5 along with the next most concise data set; those taken during 24 June - 29 July 1977, a period of well development and drilling operations. Plates 11 and 12 are water table maps based on these measurements. Appendix A contains the stabilized groundwater measurements made during this study.

Subsurface Cross Sections

Subsurface cross sections (Plates 5-10) were constructed to show the near-surface ($<$2 metres) distribution of USCS soil types along the selected traverses at PBA. These traverses were selected to cross the different geologic formations and the major concentrations of known surface contamination (see Plate 4 for cross section locations). A discussion of each cross section is presented in the following paragraphs.

Section A-A' is along the western boundary of the PBA and crosses the Jackson Group and the Pleistocene terrace deposits. A predominance

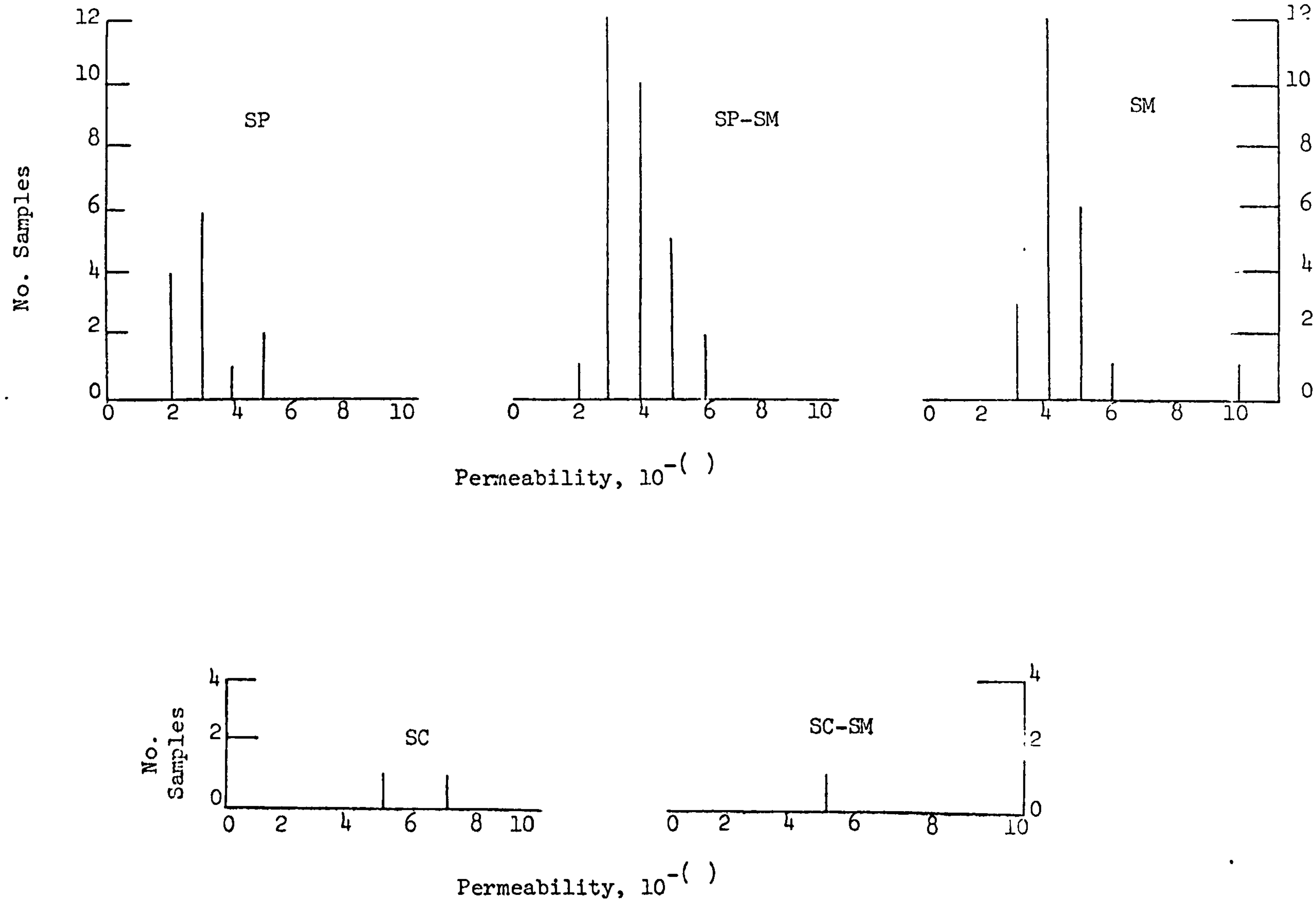


Figure 12. Distribution of Permeabilities
in Coarse-Grained Soils

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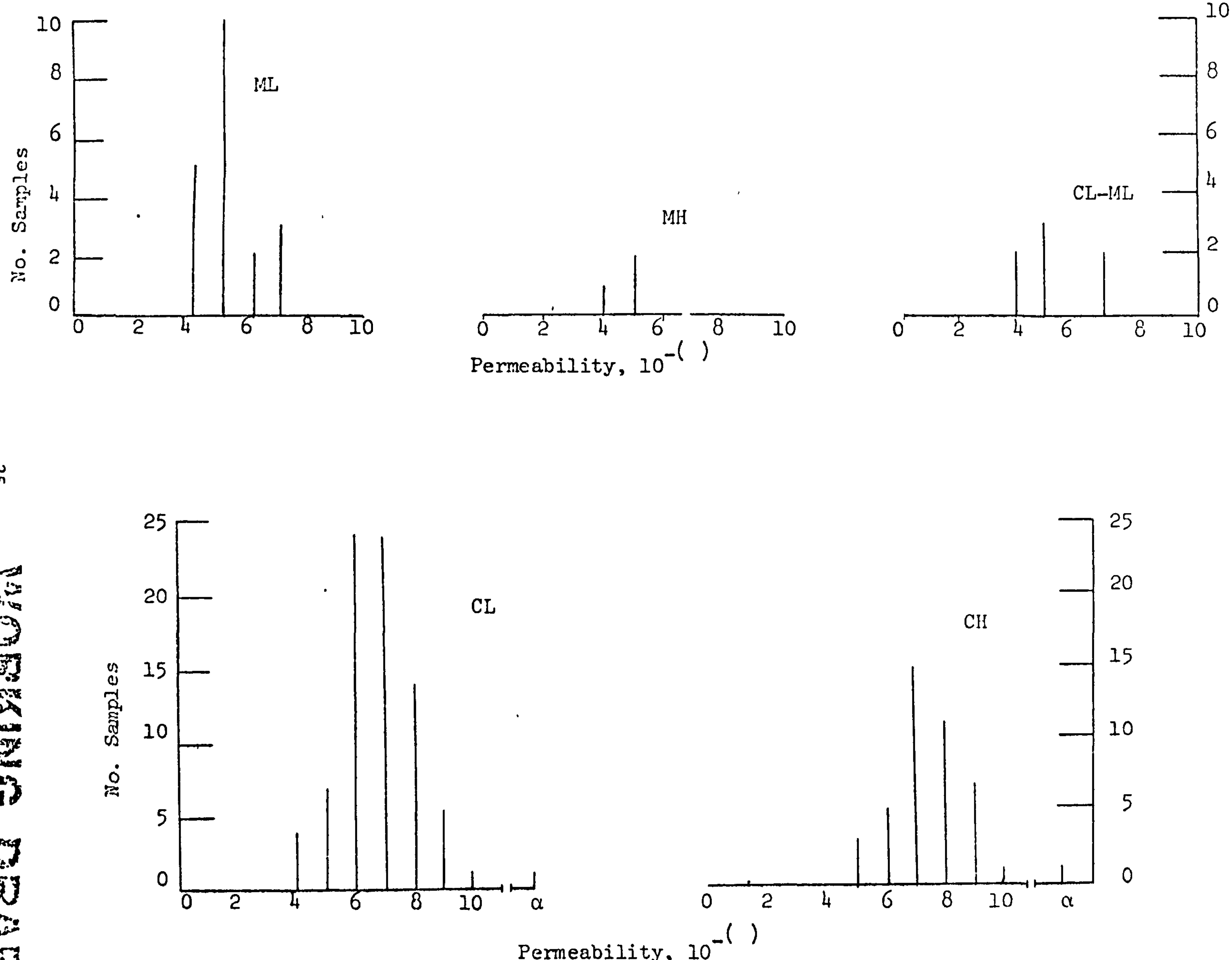

Figure 13. Distribution of Permeabilities
in Fine-Grained Soils

of fine-grained material, i.e silts (ML and MH) and clays (CL and CH) is apparent. Boring No. 89 is along side an intermittent stream and shows the effect that drainageways have on the water table in the Jackson Group. In contrast, the water table in a larger stream dissecting the terrace is at about the same elevation.

Section B-B' is along the northern boundary of the PBA and NCTR. This traverse crosses the Jackson Group, the terrace, and the meander belt deposits. One boring (No. 94) is in a small creek and has a veneer of coarse-grained material while two borings (Nos. 97 and 99) are on a terrace remnant. The water table exhibits the usual steep gradient in the higher, fine-grained deposits of the Jackson Group and a shallow gradient in the coarser-grained meander belt deposits.

Section C-C' is along the eastern boundary of the PBA and borders the Arkansas River in the northern sector (boring No. 102 to boring No. 8). This section crosses meander belt deposits in the north and Pleistocene Terrace deposits in the south. A melange of coarse-grained and fine-grained deposits characterize the surface of the meander belt deposits and the surficial terrace deposits are fine-grained. The water table shows little variation along this section. This relatively constant level is attributed to the position of the section (perpendicular to general water table gradient) and the proximity of the Arkansas River.

Section D-D' is in the northern portion of the PBA and crosses the DDT area. This section traverses the Jackson Group deposits and the Pleistocene Terrace before dipping down to meander belt deposits at boring No. 52. Fine-grained deposits are present in the Jackson Group and the surficial deposits of both the terrace and meander belt deposits are fine-grained. An elevated, steeply sloping water table is shown in the fine-grained Jackson Group in contrast to water table in the terrace and meander belt deposits which exhibits a nearly flat-lying, lower water table. The higher elevation and steeper gradient in the Jackson Group are due to the higher surface elevation and lower permeabilities of the Jackson Group.

Section E-E' is in the south-central portion of the PBA and crosses terrace deposits and meander belt deposits. The section extends from the western boundary (boring No. 75), passes the head of White Creek and south of the old sanitary landfill, and terminates on the eastern boundary with fine-grained meander belt deposits (boring No. 31). This entire section is predominantly fine-grained deposits. Boring No. 75 (western end) shows an elevated water table which is probably due to the proximity of the Jackson Group deposits but the remainder of the section shows the characteristic low gradient and deeper water table of the terrace and meander belt deposits.

Section F-F' traverses the central portion of the PBA in a generally north-south direction. It crosses deposits of the Jackson Group, Pleistocene Terrace, and Recent alluvium. This section passes through the DDT area and skirts the northern perimeter of the old sanitary landfill before terminating on the southern boundary at boring No. 58. Fine-grained surficial deposits of the Jackson Group and Pleistocene Terrace predominate the section and the usual elevated water table of the Jackson Group and the flat-lying lower water table of the terrace aquifer is present. The single alluvium boring (No. 6) has a series of coarse-grained and fine-grained deposits and the water table closely approximates the surface water level of the adjoining creek which is a tributary of the Arkansas River.

Vertical Migration of Contaminants

Vertical migration of contaminants is governed by the solubility of the contaminant, the permeability of the soil, and the driving force or hydraulic head applied to the solution. This head may be provided either by contaminated liquid or rainfall. At the PBA, both of these conditions could be met. To combat vertical migration, deny the contaminant to the environment and/or enhance the factors which decrease permeability of the soil and/or the hydraulic head. These are practiced at PBA by cessation of surface or subsurface disposal of contaminants and the covering of contaminated areas with low permeability soils. The susceptibility of the PBA to problems with vertical migration depends on the surface materials which contaminants come in contact.

The presence of coarse-grained soils (Plates 2 and 3) in alluvial deposits and terraces have potential for vertical movement of contaminants from the surface to the water table aquifer. However, the potential is reduced by the presence of a hardpan at shallow depths (1-2 m) over most of the PBA. The terrace surface material consisting primarily of silts and silty sands is underlain by finer-grained materials (clays at a depth of 1-2 m), which should retard the vertical migration to depth. The only area of the PBA subject to rapid infiltration and percolation to the water table is the Arkansas River floodplain. This area was mapped as meander belt deposits on the geology map and silty sand on the soils map. Several borings in this area (8, 9, 49, 51, 52, and 79) show the predominance of coarse-grained materials from ground surface to the water table (see Plate 8). The predominance of fine-grained surface soils on the cross sections presented on Plates 5, 6, 8, 9, and 10 should retard vertical migration on the terrace and Jackson Group. The predominance of coarse-grained deposits in the meander belt deposits offer virtually no resistance to migration between the ground surface and the water table.

Subsurface Horizontal Migration of Contaminants

The potential for subsurface horizontal migration of contaminants is dependent upon the contaminants reaching into the groundwater. After entering the groundwater, the rate of horizontal contaminant migration is dependent upon the permeability of the aquifer and the driving force or hydraulic head.

The water table maps show two distinct groundwater gradients, both moving to the east. The Quaternary surface (see Plate 2) is underlain by a water table which approximates river level and dips gently toward the river. Water table in the Jackson Group slopes rather sharply to the east and lies at a higher elevation than in the Quaternary. While the water table maps show a continuous, one directional groundwater basin (easterly) flow covering the entire PBA, it is probable that due to surface elevation differences within the Jackson, the groundwater in the northwestern portions of the PBA is feeding the stream in the adjacent alluvium. However, the prime objective of this study was to define off-post flow which is to the east. Some of the water levels in the northwest sector closely approximate the surface flow levels in the topographic lows before joining the general trends of flow to the east. The intricacies (Plates 5 and 6) of groundwater flow in the northwest sector are not relevant.

The higher gradients in the Jackson Group (Plates 5, 6, and 8) are not interpreted as indicating either a greater velocity or larger volume than the lower gradients in the Pleistocene Terrace, meander belt deposits, or alluvium. This is the result of the thinner, discontinuous, lower permeability saturated zones of the Jackson Group as compared to the other deposits.

Total mass flow passing beneath the PBA cannot be calculated due to the lack of data on the total saturated thickness of the aquifer. An estimate of groundwater velocity may be obtained from the equation:

$$v = \frac{ki}{p}$$

where v = groundwater velocity

k = permeability

i = hydraulic gradient

p = porosity

Using the general values of:

k = .01 cm/sec in the terrace and meander belt deposits

k = .0001 in the Jackson Group

i = .0008 in the terrace and meander belt deposits

i = .007 in the Jackson Group

p = .3 for all deposits

Solving for velocity gives values of 84 m/yr in the terrace and floodplain and 70 m/yr in the Jackson Group. These values are probably in the right order of magnitude but site specific data would be required for precise estimates.

Surface Storage of Hazardous Waste

Safe storage of hazardous or toxic waste requires detailed planning, precise execution, and scrupulous monitoring. Because of the potential for vertical and horizontal subsurface migration of contaminants at PBA, any contaminant storage must be properly planned and monitored. Detailed site specific investigations will be required at any candidate storage site to define the strata between the ground surface and the water table as well as the gradient and hydraulic conductivity of the water table aquifer. In the absence of a verifiable, thick, low permeability strata, site enhancement procedures will be required. Site preparation may range from simply mixing an extremely low permeable material in the final surface of the storage area to placing an impermeable base of cement, asphalt, membranes, chemical additive, etc. Requirements for a storage site must also include provisions for a system to prevent surface water (rainfall runoff) from coming in contact with the materials and installing a groundwater monitoring system by placing a network of wells around the site. The hydrogeologic characteristics of the Jackson Group deposits are more suitable for a storage site than the Pleistocene Terrace. However, the procedures discussed above for site preparation must be followed regardless of the location. The floodplain should be completely eliminated from any consideration.

PART V: CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The potential for the vertical migration of contaminants to the water table and the subsequent easterly movement of these contaminants off-post exists at the PBA. That portion of PBA occupied by the Jackson Group sediments is least susceptible to the vertical migration; the Pleistocene Terrace is the next most resistant; and the meander belt deposits and alluvium are very susceptible to the vertical migration of contaminants. The Pleistocene Terrace, the meander belt deposits, and the alluvium are very susceptible to the horizontal migration of contaminants after entering the groundwater. The Jackson Group of sediments offer some resistance to the horizontal migration of contaminants because of their fine-grained characteristics.

The Jackson Group sediments contain the best candidate sites to securely store any soluble toxic material. This surface at a proposed storage site will require extensive site investigation and probably substantial engineering improvements. However, detailed investigations and appropriate engineering improvements should make limited storage feasible. The Quaternary surface of PBA will require extensive engineering effort to securely store any soluble toxic material. Even these improvements should be limited to the higher elevations of the terrace surface. The floodplain of the Arkansas River should not be considered.

Recommendations

The monitoring wells installed during this study can furnish an understanding of the groundwater regime of the PBA and aid in evaluating the chemistry of the groundwater through a systematic water level measurement and water sampling and analysis program. Groundwater measurements and sampling should be made on a monthly basis for at least a year to establish trends and then quarterly to verify the trends. Subsequent years should have measurements made at the time of maximum and minimum groundwater elevations as established during the first two years.

Additional monitoring points are not recommended at present but may be required to refine the definition of the groundwater regime in critical areas or to verify any contaminant movement should chemical analyses indicate the presence of contaminants. The location of these additional monitoring points should be determined by a careful analysis of the hydrogeology and groundwater chemistry of the area in question.

Table 1

Materials Used in PBA Operations

Acetone, ketones
Agar - Agar
Alcohols, solvents
Aluminum, powder, or grained
Animal protein
Barium chromate
Barium nitrate
BZ
Calcium carbonate
Caustic
Cellulose nitrate-camphor
Cellulose nitrate
Charcoal
Chloracetophenone (CN)
Chlorates
Chlorine
Chromates
CS
Cysteine HCl
Dextrine
Dextrose
Diatomaceous earth
Dipyridyl
Dye, green
Dye, red
Dye, yellow
Fuller's earth
Glycene
Graphite
Hexachlorethane
Hydrochloric acid
Iron oxide
Lactose
Lard oil
Lead oxide (red lead)
Magnesium carbonate
Magnesium hydroxide
Magnesium powder
Metal powders
Nitrates (inorganic)
Nitrocellulose (wet)
Perchlorates
Phosphorus, red
Phosphorus, white
Plant protein
Potassium bicarbonate
Potassium chlorate
Potassium nitrate
Protamine sulphate
Quaternary ammonium compound (50% solution)
Raffinose
Resin
Silicone
Silicone antifoams
Skim milk solids
Soda, sodium bicarbonate
Sodium chloride
Sodium nitrate
Sodium sulfate
Sucrose
Sugar, powdered
Sulphur
Sulfuric acid
Thermit
Thiamine HCl
Thiourea
Titanium, powdered
Tricalcium phosphate
Tryptose
Zinc borate
Zinc oxide

Table 2

Schedule of Monitoring Wells

Well number*	Manufacturing area monitored	Location
1a/	Chlorine**	Near building 54-360 acetylene generator
2b/	Chlorine**	Between buildings 53-810 and 50-910
3c/	Chlorine**	Between buildings 53-110 and 53-220
4	Storage depot	Webster Road
5R	WP	Near creek receiving WP plant waste
6	WP	Near WP waste system
7	HC	Off Stokes Road near Avenue 34-B
8	HC	On Stokes Road
9	Smokes	338 Street near Avenue 331-A
10	Smokes	Near building 33-670
11	BZ	Avenue 321-A
12	BZ	Near building 32-690
13	CN, CS	Avenue 311-A near building 31-570
14	CN, CS	Building 31-830 and building 31-840
15	CN, CS	Avenue 311-B and 310 Street
16R	HC	Sibert Road
17R	Contaminated ditch near McCoy Road	

* R = Existing wells rehabilitated.
** ARKLA Chemical Co.
a/ Drilled to depth of 135 feet without evidence of water. Abandoned as a dry hole.
b/ Drilled to depth in excess of 100 feet. Abandoned as a dry hole.
c/ Drilled to 685 feet to reach water. This was done by PBA in an attempt to prove the absence of useful groundwater for monitoring in the area of the leased chemical facility.

Table 3

Distribution of Permeabilities According to Soil Types

Soil Type (USCS)	Permeability, cm/sec				No. Samples
	Maximum	Minimum	Mean	Average	
SP	2.00×10^{-2}	5.30×10^{-5}	5.60×10^{-3}	6.63×10^{-3}	13
SP-SM	1.50×10^{-2}	3.50×10^{-6}	5.85×10^{-4}	1.97×10^{-3}	20
SM	8.30×10^{-3}	6.90×10^{-10}	3.80×10^{-4}	7.39×10^{-4}	23
SC-SM	1.48×10^{-5}	1.48×10^{-5}	1.48×10^{-5}	1.48×10^{-5}	1
SC	2.74×10^{-5}	5.44×10^{-7}	1.40×10^{-5}	1.40×10^{-5}	2
ML	6.90×10^{-4}	1.03×10^{-7}	3.00×10^{-5}	1.22×10^{-4}	20
MH	1.30×10^{-4}	1.20×10^{-5}	3.00×10^{-5}	5.73×10^{-5}	3
CL-ML	2.30×10^{-4}	1.90×10^{-7}	2.40×10^{-5}	6.50×10^{-5}	7
CL	1.40×10^{-4}	0.00	8.30×10^{-7}	8.09×10^{-6}	79
CH	6.20×10^{-5}	0.00	1.20×10^{-7}	2.71×10^{-6}	43

Table 4. Physical Test Results

Boring No.	Sample Depth, cm	Atterberg Limits, Percent Water: Liquid Limit	Atterberg Limits, Percent Water: Plastic Limit	USCS Classification	Water Content, %	Density, g/cc	Permeability, cm/sec
1	29-67	22.0	16.0	CL-ML			
1	124-174	21.0	17.0	SM			
1	324-347	NP	NP	SM			
1	599-648	31.0	16.0	CL			
1	874-918	32.0	17.0	CL	20.7	1.67	
1	1174-1184	26.0	19.0	CL	24.6	1.57	2.3×10^{-7}
1	1449-1500	NP	NP	SP-SM		1.60	1.9×10^{-3}
2	24-70	26.0	18.0	CL			
2	124-160	38.0	17.0	CL			
2	324-373	29.0	18.0	CL			
2	619-665	32.0	12.0	CL			
2	914-947	32.0	15.0	CL			
2	1209-1233	55.0	20.0	CH	21.5	1.67	
2	1509-1543	29.0	17.0	CL	27.9	1.51	2.2×10^{-7}
3	29-70	43.0	16.0	CL			
3	179-225	30.0	18.0	CL	10.4	1.67	7.7×10^{-6}
3	329-375	22.0	15.0	CL	7.5	1.90	9.8×10^{-8}
3	629-675	51.0	16.0	CH			
3	779-824	26.0	12.0	CL			
3	929-974	32.0	17.0	CL			
3	1079-1124	NP	NP	ML			
3	1229-1268	NP	NP	SP			
3	1679-1720	NP	NP	SP-SM		1.67	4.0×10^{-6}
4	29-75	23.0	16.0	CL-ML			
4	129-170	30.0	16.0	CL	22.2	1.58	
4	325-371	37.0	14.0	CL			
4	646-692	29.0	15.0	CL			
4	963-995	NP	NP	ML			
4	1275-1325	NP	NP	SM	15.4	1.68	3.3×10^{-5}
4	1570-1615	NP	NP	SP		1.63	5.3×10^{-5}
5	75-145	43.0	18.0	CL	30.4	1.46	3.8×10^{-7}
5	179-224	60.0	23.0	CH	39.8	1.23	1.2×10^{-7}
5	389-435	NP	NP	SP-SM		1.58	3.2×10^{-3}
6	24-61	NP	NP	SM			
6	124-170	NP	NP	SM			
6	224-275	61.0	24.0	CH	35.7	1.27	
6	399-425	NP	NP	SP	24.2	1.47	1.2×10^{-2}
6	604-655	68.0	23.0	CH	40.6	1.25	7.5×10^{-8}
7	24-74	22.0	16.0	CL-ML	20.7	1.58	
7	119-143	34.0	15.0	CL	22.5	1.54	1.5×10^{-7}
7	324-374	28.0	15.0	CL			
7	654-705	29.0	13.0	CL			

(Continued)

Table 4. Physical Test Results

Boring No.	Sample Depth, cm	Atterberg Limits, Percent Water: Liquid Limit	Atterberg Limits, Percent Water: Plastic Limit	USCS Classification	Water Content, %	Density, g/cc	Permeability, cm/sec
7	984-1035	33.0	18.0	CL			
7	1314-1365	31.0	17.0	CL			
7	1574-1625	NP	NP	SP-SM		1.57	1.1×10^{-3}
7	1665-1669	NP	NP	SP			
8	29-75	NP	NP	SP			
8	129-175	NP	NP	SP			
8	229-275	NP	NP	SP	4.4	1.52	
8	329-375	NP	NP	SP			
8	429-475	NP	NP	SP		1.53	2.0×10^{-2}
8	754-800	NP	NP	SP-SM		1.61	1.5×10^{-3}
9	29-57	NP	NP	ML			
9	129-165	NP	NP	ML			
9	229-275	NP	NP	SP	3.1	1.54	
9	329-375	NP	NP	SP			
9	479-525	NP	NP	SP			
9	654-700	NP	NP	SM	27.6	1.52	1.1×10^{-3}
9	945-1007	NP	NP	SM		1.65	8.5×10^{-4}
10	24-55	20.0	16.0	SM			
10	129-150	28.0	19.0	CL			
10	329-375	47.0	14.0	CL			
10	639-685	41.0	15.0	CL	19.8	1.71	
10	949-995	27.0	17.0	CL			
10	1259-1305	NP	NP	SP-SM		1.62	5.8×10^{-4}
10	1559-1605	NP	NP	SP-SM		1.62	1.6×10^{-3}
11	24-57	NP	NP	ML			
11	129-173	NP	NP	SP-SM	8.7	1.43	
11	229-275	NP	NP	SM			
11	325-373	NP	NP	SP-SM			
11	454-496	NP	NP	SM	22.6	1.54	1.5×10^{-3}
11	749-790	NP	NP	SP-SM		1.65	3.4×10^{-3}
12	24-70	31.0	18.0	CL			
12	124-165	36.0	17.0	CL	17.8	1.67	1.0×10^{-5}
12	324-350	26.0	12.0	CL			
12	619-645	39.0	18.0	CL			
12	914-965	62.0	24.0	CH			
12	1209-1242	NP	NP	SM	11.9	1.67	6.7×10^{-4}
12	1364-1405	NP	NP	SP		1.54	1.0×10^{-2}
13	29-66	25.0	16.0	CL			
13	129-162	26.0	17.0	CL			

(Continued)

Table 4. Physical Test Results

Boring No.	Sample Depth, cm	Atterberg Limits, Percent Water: Liquid Limit	Atterberg Limits, Percent Water: Plastic Limit	USCS Classification	Water Content, %	Density, g/cc	Permeability, cm/sec
13	329-370	21.0	16.0	CL-ML			
13	654-698	42.0	15.0	CL	19.4	1.73	
13	979-1012	26.0	18.0	CL			
13	1304-1350	NP	NP	SP		1.54	2.2×10^{-3}
13	1604-1650	NP	NP	SP-SM		1.69	1.0×10^{-5}
14	29-62	NP	NP	ML			
14	129-175	20.0	15.0	CL-ML			
14	329-375	NP	NP	SP-SM	15.2	1.79	
14	684-730	36.0	14.0	CL			
14	1039-1085	32.0	14.0	CL			
14	1394-1432	66.0	24.0	CH			
14	1494-1540	54.0	16.0	CH	20.5	1.56	3.3×10^{-9}
14	1590-1625	NP	NP	SP			
14	1694-1730	NP	NP	SP-SM		1.68	9.4×10^{-4}
15	30-100	39.0	16.0	CL	15.9	1.76	4.9×10^{-7}
15	134-160	34.0	15.0	CL			
15	329-373	26.0	20.0	CL-ML			
15	629-673	39.0	14.0	CL	18.8	1.75	
15	929-975	NP	NP	SM			
15	1229-1275	NP	NP	SP-SM		1.58	1.3×10^{-3}
16	24-51	NP	NP	SM			
16	124-160	29.0	19.0	CL			
16	329-375	42.0	15.0	CL			
16	524-560	27.0	15.0	CL			
16	724-760	74.0	24.0	CH			
16	924-960	69.0	23.0	CH	33.9	1.41	
16	1029-1075	44.0	14.0	CL			
16	1129-1175	NP	NP	SP-SM		1.76	1.5×10^{-2}
17	24-75	25.0	19.0	CL-ML			
17	119-140	37.0	18.0	CL			
17	324-375	36.0	15.0	CL	15.5	1.94	5.8×10^{-8}
17	613-660	34.0	18.0	CL	16.9	1.75	
17	898-942	NP	NP	SM			
17	1183-1230	NP	NP	SP-SM	16.4	1.42	8.0×10^{-3}
17	1470-1492	NP	NP	SP-SM			
18	33-75	22.0	15.0	CL	16.0	1.76	
18	133-175	33.0	16.0	CL	9.3	1.81	
18	333-369	NP	NP	SM			
18	668-695	50.0	17.0	CL	19.5	1.70	4.6×10^{-9}

(Continued)

Table 4. Physical Test Results

Boring No.	Sample Depth, cm	Atterberg Limits, Percent Water: Liquid Limit	Plastic Limit	USCS Classification	Water Content, %	Density, g/cc	Permeability, cm/sec
18	1003-1045	44.0	15.0	CL			
18	1333-1354	69.0	20.0	CH			
18	1488-1530	NP	NP	SP	2.6	1.63	1.0×10^{-2}
18	1678-1711	NP	NP	SM			
19	33-75	29.0	15.0	CL			
19	128-155	29.0	15.0	CL			
19	328-368	35.0	14.0	CL	12.6	1.77	1.2×10^{-6}
19	678-702	33.0	15.0	CL			
19	1028-1060	27.0	16.0	CL	8.3	1.81	
19	1383-1425	32.0	15.0	CL	20.1	1.64	1.2×10^{-6}
19	1533-1575	NP	NP	SM			
19	1670-1690	NP	NP	SP			
20	33-75	27.0	18.0	CL			
20	128-145	34.0	17.0	CL			
20	333-363	NP	NP	SM			
20	668-710	41.0	13.0	CL	12.4	1.89	2.2×10^{-8}
20	998-1020	23.0	17.0	CL-ML			
20	1333-1375	54.0	25.0	CH			
20	1488-1530	45.0	20.0	CL	28.6	1.48	4.7×10^{-6}
20	1630-1670	24.0	14.0	CL			
21	33-60	38.0	16.0	CL			
21	128-160	36.0	16.0	CL			
21	324-350	26.0	18.0	CL	51.3	1.32	4.7×10^{-6}
21	633-675	37.0	13.0	CL	14.8	1.80	
21	943-985	29.0	17.0	CL			
21	1248-1290	NP	NP	SM	14.5	1.54	2.2×10^{-5}
21	1540-1590	NP	NP	SP-SM			
22	28-75	30.0	17.0	CL			
22	128-170	50.0	14.0	CL	12.0	1.59	1.5×10^{-5}
22	328-373	24.0	13.0	CL	6.3	1.89	
22	613-660	30.0	15.0	CL			
22	898-945	30.0	16.0	CL			
22	1183-1230	NP	NP	SP-SM	11.7	1.61	1.2×10^{-3}
22	1333-1380	NP	NP	SP			
22	1585-1596	NP	NP	SP			
23	28-75	33.0	20.0	CL			
23	120-131	31.0	17.0	CL			
23	328-358	24.0	17.0	CL-ML	5.8	1.86	
23	683-725	36.0	15.0	CL	16.8	1.80	

(Continued)

Table 4. Physical Test Results

oring No.	Sample Depth, cm	Atterberg Limits, Percent Water Liquid Limit	Plastic Limit	USCS Classification	Water Content, %	Density, g/cc	Permeability, cm/sec
23	1038-1085	NP	NP	SP-SM	13.1	1.53	1.9×10^{-4}
23	1393-1440	NP	NP	SP	12.5	1.66	$4.2 \times 10^{-}$[illegible]
23	1680-1700	NP	NP	SP-SM			
24	28-65	26.0	19.0	CL			
24	125-165	28.0	16.0	CL	12.9	1.65	8.2×10^{-6}
24	328-360	NP	NP	SM			
24	713-760	46.0	15.0	CL			
24	1098-1145	34.0	15.0	CL	17.5	1.81	
24	1483-1530	NP	NP	SM			
24	1770-1823	NP	NP	SP-SM	18.6	1.73	5.9×10^{-4}
25	28-75	19.0	14.0	CL-ML	17.6	1.68	7.1×10^{-5}
25	128-175	30.0	13.0	CL	12.5	1.89	
25	328-365	58.0	18.0	CH			
25	690-716	30.0	22.0	CL			
25	1068-1115	30.0	16.0	CL			
25	1428-1475	NP	NP	SM	13.9	1.58	8.3×10^{-3}
25	1730-1780	NP	NP	SP			
26	28-75	NP	NP	ML	18.4	1.32	
26	124-167	41.0	15.0	CL	17.8	1.73	1.0×10^{-6}
26	324-355	NP	NP	SM	2.9	1.54	
26	663-710	47.0	16.0	CL			
26	994-1017	NP	NP	SM			
26	1333-1380	NP	NP	SP	10.1	1.61	6.8×10^{-4}
26	1620-1658	NP	NP	SM			
27	25-75	25.0	16.0	CL			
27	128-175	24.0	16.0	CL	16.5	1.73	1.1×10^{-5}
27	324-375	34.0	13.0	CL			
27	709-760	43.0	16.0	CL			
27	1098-1145	48.0	19.0	CL	25.1	1.60	
27	1479-1530	32.0	17.0	CL			
27	1779-1819	21.0	13.0	CL	20.2	1.66	5.9×10^{-6}
28	28-57	40.0	16.0	CL			
28	128-175	17.0	15.0	SM			
28	328-375	60.0	19.0	CH	24.6	1.56	1.6×10^{-9}
28	744-795	26.0	16.0	CL	16.2	1.60	4.0×10^{-7}
28	1124-1144	65.0	22.0	CH			
28	1584-1605	40.0	24.0	CL	23.7	1.56	
29	24-61	24.0	15.0	CL	18.6	1.60	
29	128-175	31.0	15.0	CL	17.0	1.64	1.4×10^{-6}

(Continued)

Table 4. Physical Test Results

Boring No.	Sample Depth, cm	Atterberg Limits, Percent Water: Liquid Limit	Atterberg Limits, Percent Water: Plastic Limit	USCS Classification	Water Content, %	Density, g/cc	Permeability, cm/sec
29	328-348	41.0	14.0	CL			
29	818-865	38.0	16.0	CL	20.0	1.46	1.2×10^{-5}
29	1304-1322	NP	NP	SM			
30	63-85	NP	NP	SM			
30	143-184	26.0	10.0	CL			
30	400-450	NP	NP	ML			
30	713-753	51.0	14.0	CH	18.6	1.74	
30	1093-1135	27.0	20.0	CL-ML	24.1	1.57	1.9×10^{-7}
30	1465-1510	NP	NP	SP-SM		1.56	1.7×10^{-4}
30	1755-1797	NP	NP	SM			
31	20-47	61.0	22.0	CH	29.2	1.47	2.1×10^{-8}
31	108-150	NP	NP	ML	29.9	1.48	2.8×10^{-5}
31	408-450	33.00		CL	32.1	1.41	
32	33-70	24.0	17.0	CL-ML	19.7	1.59	
32	128-155	32.0	16.0	CL	17.5	1.69	2.4×10^{-8}
32	329-375	29.0	20.0	CL			
32	574-620	54.0	18.0	CH			
32	815-835	32.0	19.0	CL			
32	1060-1120	NP	NP	SP-SM	20.4	1.49	5.0×10^{-4}
32	1368-1410	NP	NP	SM			
33	25-45	38.0	15.0	CL			
33	128-175	28.0	12.0	CL	15.3	1.79	7.8×10^{-8}
33	328-375	NP	NP	SM		1.73	3.8×10^{-4}
33	628-675	NP	NP	SP-SM			
34	28-65	31.0	13.0	CL			
34	128-175	34.0	14.0	CL			
34	328-375	NP	NP	SM			
34	525-558	47.0	16.0	CL	19.9	1.70	9.7×10^{-8}
34	718-762	47.0	16.0	CL			
34	913-944	58.0	26.0	CH			
34	1013-1060	34.0	14.0	CL			
34	1113-1160	NP	NP	SP-SM		1.73	3.5×10^{-6}
34	1200-1226	NP	NP	SP-SM	17.2	1.69	
35	23-76	24.0	18.0	CL-ML			
35	123-160	38.0	16.0	CL			
35	328-375	39.0	14.0	CL	16.4	1.73	2.3×10^{-8}
35	553-593	53.0	16.0	CH			
35	783-822	50.0	22.0	CH			
35	1013-1065	NP	NP	ML	18.2	1.62	4.1×10^{-5}
35	1310-1344	NP	NP	SP			

(Continued)

Table 4. Physical Test Results

Boring No.	Sample Depth, cm	Atterberg Limits, Percent Water: Liquid Limit	Atterberg Limits, Percent Water: Plastic Limit	USCS Classification	Water Content, %	Density, g/cc	Permeability, cm/sec
36	28-65	25.0	18.0	CL-ML			
36	134-149	30.0	19.0	CL			
36	335-350	26.0	16.0	CL			
36	563-590	42.0	13.0	CL	9.1	1.89	9.1×10^{-9}
36	798-825	53.0	20.0	CH			
36	1030-1050	NP	NP	SM			
36	1133-1180	24.0	21.0	ML			
36	1330-1358	NP	NP	SP		1.56	9.4×10^{-3}
37	28-93	33.0	15.0	CL			
37	128-163	33.0	14.0	CL			
37	328-370	28.0	13.0	CL			
37	568-615	23.0	16.0	CL-ML			
37	808-840	65.0	25.0	CH	17.2	1.68	8.8×10^{-10}
37	1048-1090	NP	NP	SP-SM		1.59	4.6×10^{-4}
37	1340-1385	NP	NP	SP			
38	28-47	34.0	16.0	CL			
38	128-164	33.0	15.0	CL			
38	323-353	27.0	16.0	CL			
38	528-575	45.0	16.0	CL	17.0	1.79	1.5×10^{-8}
38	723-775	NP	NP	ML	15.1	1.66	
38	923-975	NP	NP	SP-SM		1.40	5.0×10^{-5}
38	1220-1265	NP	NP	SM			
39	28-86	29.0	17.0	CL	15.2	1.71	1.2×10^{-6}
39	125-168	NP	NP	ML			
39	328-373	NP	NP	SM			
39	588-635	38.0	12.0	CL	15.2	1.81	
39	848-895	38.0	15.0	CL			
39	1108-1155	65.0	24.0	CH			
39	1258-1305	53.0	18.0	CH	13.1	1.42	
39	1478-1515	NP	NP	SP		1.71	8.8×10^{-5}
40	28-54	NP	NP	ML			
40	128-160	34.0	16.0	CL	17.0	1.70	1.6×10^{-6}
40	328-375	21.0	15.0	CL-ML			
40	628-675	52.0	15.0	CH			
40	930-945	NP	NP	ML			
40	1235-1290	NP	NP	SP-SM		1.50	4.4×10^{-4}
40	1535-1590	NP	NP	SM			
41	30-75	37.0	15.0	CL			
41	138-175	36.0	16.0	CL			

(Continued)

Table 4. Physical Test Results

Boring No.	Sample Depth, cm	Atterberg Limits, Percent Water: Liquid Limit	Atterberg Limits, Percent Water: Plastic Limit	USCS Classification	Water Content, %	Density, g/cc	Permeability, cm/sec
41	328-375	NP	NP	SP			
41	573-620	47.0	15.0	CL	22.9	1.65	
41	818-865	NP	NP	SP-SM		1.67	3.6×10^{-4}
41	1055-1110	NP	NP	SP		1.54	5.6×10^{-3}
41	1355-1410	NP	NP	SP-SM			
42	20-55	25.0	17.0	CL			
42	123-180	31.0	16.0	CL			
42	328-375	35.0	13.0	CL			
42	613-648	33.0	12.0	CL			
42	898-926	50.0	16.0	CH			
42	1183-1220	83.0	21.0	CH			
42	1283-1330	67.0	26.0	CH	34.2	1.42	2.1×10^{-9}
42	1383-1415	NP	NP	SM			
42	1495-1535	27.0	13.0	CL	21.8	1.58	1.6×10^{-7}
43	0-36	24.0	16.0	CL			
43	128-160	50.0	14.0	CH			
43	328-375	53.0	30.0	MH			
43	553-600	77.0	31.0	CH			
43	765-795	NP	NP	SM			
43	1003-1050	30.0	28.0	ML	22.9	1.47	6.4×10^{-5}
43	1303-1350	50.0	27.0	CL	32.7	1.36	2.0×10^{-7}
44	23-43	38.0	15.0	CL			
44	135-197	22.0	18.0	CL-ML	21.7	1.63	7.7×10^{-7}
44	328-375	NP	NP	SM	15.7	1.87	
44	458-505	55.0	28.0	CH			
44	583-635	50.0	23.0	CL			
44	713-765	51.0	21.0	CH			
44	1018-1065	NP	NP	ML	23.5	1.46	1.7×10^{-5}
45	25-85	40.0	17.0	CL	21.8	1.58	3.5×10^{-8}
45	123-157	57.0	24.0	CH	39.9	1.26	
45	328-365	76.0	36.0	MH			
45	448-487	58.0	26.0	CH			
45	608-653	54.0	35.0	MH			
45	748-775	NP	NP	ML			
45	1043-1075	24.0	17.0	CL-ML	33.8	1.24	2.4×10^{-5}
45	1348-1395	38.0	24.0	CL			
46	28-75	30.0	16.0	CL			
46	128-175	23.0	17.0	CL-ML	12.8	1.91	1.2×10^{-5}
46	323-353	34.0	17.0	CL	15.2	1.70	

(Continued)

Table 4. Physical Test Results

Boring No.	Sample Depth, cm	Atterberg Limits, Percent Water: Liquid Limit	Atterberg Limits, Percent Water: Plastic Limit	USCS Classification	Water Content, %	Density, g/cc	Permeability, cm/sec
46	528-575	55.0	21.0	CH			
46	728-773	61.0	29.0	CH			
46	920-945	53.0	32.0	MH	34.0	1.25	1.3×10^{-4}
46	1228-1275	49.0	32.0	ML			
47	28-55	NP	NP	SM	17.0	1.69	
47	120-155	NP	NP	SM			
47	215-250	NP	NP	SP-SM			
47	528-575	60.0	28.0	CH	40.4	1.22	2.5×10^{-7}
47	823-851	36.0	22.0	CL	28.7	1.43	
48	28-75	NP	NP	SP			
48	128-175	46.0	14.0	CL			
48	328-375	37.0	16.0	CL	18.9	1.74	
48	428-460	38.0	14.0	CL			
48	528-567	70.0	23.0	CH			
48	620-685	54.0	21.0	CH	25.1	1.60	1.2×10^{-8}
48	778-825	NP	NP	SM			
48	980-1020	NP	NP	SP	15.3	1.65	4.6×10^{-3}
49	28-75	NP	NP	SP			
49	123-153	NP	NP	ML	25.6	1.43	3.2×10^{-5}
49	330-375	NP	NP	SP			
49	428-475	NP	NP	SP-SM	4.5	1.58	
49	530-575	NP	NP	SP			
49	628-675	NP	NP	SP-SM	19.3	1.49	7.3×10^{-3}
49	915-945	NP	NP	SP			
50	28-70	28.0	21.0	CL-ML			
50	128-170	29.0	20.0	CL	24.2	1.51	1.7×10^{-6}
50	228-256	NP	NP	ML			
50	328-370	NP	NP	ML	22.7	1.56	
50	428-465	NP	NP	ML			
50	728-775	NP	NP	ML	20.3	1.54	6.9×10^{-4}
51	20-75	NP	NP	SM			
51	123-175	NP	NP	ML	15.1	1.49	5.1×10^{-4}
51	323-375	NP	NP	ML			
51	438-490	NP	NP	SP			
51	553-605	NP	NP	SP			
51	665-720	NP	NP	SP	19.7	1.61	7.3×10^{-3}
51	965-1025	NP	NP	SP			
52	28-60	39.0	18.0	CL			
52	123-165	31.0	21.0	CL			

(Continued)

Table 4. Physical Test Results

Boring No.	Sample Depth, cm	Atterberg Limits, Percent Water: Liquid Limit	Atterberg Limits, Percent Water: Plastic Limit	USCS Classification	Water Content, %	Density, g/cc	Permeability, cm/sec
52	328-360	57.0	23.0	CH	33.4	1.41	3.4×10^{-8}
52	433-460	NP	NP	ML			
52	543-595	40.0	17.0	CL			
52	653-705	NP	NP	ML	23.9	1.42	2.0×10^{-5}
52	953-1005	NP	NP	SM			
53	23-48	28.0	18.0	CL			
53	128-175	28.0	18.0	CL			
53	228-270	60.0	20.0	CH			
53	328-370	80.0	30.0	CH			
53	428-475	72.0	23.0	CH	41.2	1.21	1.6×10^{-8}
53	528-575	53.0	19.0	CH			
53	628-675	58.0	22.0	CH	30.5	1.45	1.1×10^{-7}
53	928-950	NP	NP	ML			
54	28-55	28.0	18.0	CL			
54	128-175	34.0	17.0	CL			
54	328-375	28.0	14.0	CL	13.2	1.86	1.6×10^{-7}
54	518-565	36.0	15.0	CL			
54	708-755	25.0	17.0	CL	16.7	1.65	4.1×10^{-6}
54	893-945	30.0	17.0	CL			
54	1198-1245	26.0	15.0	CL	23.2	1.62	
55	28-70	31.0	18.0	CL			
55	128-175	35.0	17.0	CL			
55	328-369	26.0	12.0	CL	7.9	1.84	6.0×10^{-8}
55	503-550	43.0	13.0	CL			
55	678-720	NP	NP	SM			
55	853-890	NP	NP	SP-SM	25.9	1.57	3.9×10^{-4}
55	1145-1200	29.0	14.0	CL			
56	28-75	30.0	18.0	CL			
56	115-150	32.0	17.0	CL	13.0	1.73	
56	320-359	25.0	16.0	CL	9.8	1.70	8.3×10^{-7}
56	488-535	32.0	15.0	CL			
56	649-689	43.0	14.0	CL			
56	815-880	NP	NP	SM	26.4	1.50	3.1×10^{-4}
56	1115-1170	NP	NP	SP-SM			
57	23-65	27.0	19.0	CL			
57	128-165	31.0	17.0	CL			
57	328-375	29.0	13.0	CL	15.3	1.77	9.4×10^{-7}
57	468-510	39.0	13.0	CL			
57	608-640	29.0	14.0	CL	14.3	1.88	

(Continued)

Table 4. Physical Test Results

Boring No.	Sample Depth, cm	Atterberg Limits, Percent Water: Liquid Limit	Atterberg Limits, Percent Water: Plastic Limit	USCS Classification	Water Content, %	Density, g/cc	Permeability, cm/sec
57	740-795	NP	NP	SM	12.6	1.64	2.7×10^{-4}
57	1040-1095	NP	NP	SM			
58	28-75	30.0	18.0	CL			
58	128-175	30.0	14.0	CL			
58	325-360	32.0	15.0	CL			
58	455-492	51.0	13.0	CH	16.8	1.79	3.3×10^{-9}
58	582-609	49.0	14.0	CL			
58	709-746	51.0	17.0	CH	14.5	1.88	
58	836-878	49.0	18.0	CL			
58	963-1010	NP	NP	SM	17.2	1.49	2.8×10^{-5}
59	28-75	22.0	15.0	CL-ML			
59	128-175	87.0	16.0	CH			
59	328-375	NP	NP	SM			
59	488-525	53.0	18.0	CH	22.0	1.67	
59	648-695	57.0	17.0	CH	23.6	1.59	7.5×10^{-7}
59	808-840	69.0	27.0	CH			
59	958-1000	38.0	14.0	CL			
59	1103-1145	NP	NP	SP-SM	26.6	1.57	2.2×10^{-3}
60	28-75	NP	NP	ML			
60	128-170	33.0	18.0	CL	15.5	1.81	3.3×10^{-6}
60	228-275	30.0	16.0	CL			
60	320-355	NP	NP	SM			
60	420-475	NP	NP	SM	20.6	1.77	7.7×10^{-6}
60	720-772	31.0	17.0	CL			
61	28-70	NP	NP	SP-SM			
61	128-170	24.0	16.0	CL	14.4	1.69	8.8×10^{-7}
61	328-375	21.0	13.0	CL			
61	603-645	49.0	15.0	CL	19.6	1.74	0.0
61	878-925	34.0	14.0	CL			
61	1153-1200	35.0	16.0	CL			
61	1303-1350	38.0	15.0	CL			
61	1595-1645	NP	NP	SP-SM	22.1	1.60	6.5×10^{-3}
62	20-51	30.0	17.0	CL	11.2	1.85	6.2×10^{-6}
62	228-275	34.0	15.0	CL			
62	328-375	35.0	14.0	CL			
62	468-515	51.0	21.0	CH			
62	728-775	59.0	25.0	CH			
63	28-75	26.0	17.0	CL			
63	128-170	50.0	17.0	CH			

(Continued)

Table 4. Physical Test Results

Boring No.	Sample Depth, cm	Atterberg Limits, Percent Water Liquid Limit	Plastic Limit	USCS Classification	Water Content, %	Density, g/cc	Permeability, cm/sec
63	225-260	62.0	15.0	CH			
63	325-345	43.0	19.0	CL	22.3	1.58	9.0×10^{-8}
63	450-520	38.0	28.0	ML	30.9	1.42	1.0×10^{-5}
63	628-675	50.0	22.0	CL			
64	28-70	24.0	16.0	CL			
64	120-165	51.0	15.0	CH			
64	220-275	24.0	16.0	CL	24.2	1.57	2.0×10^{-7}
64	328-375	55.0	24.0	CH	42.2	1.20	2.3×10^{-8}
64	428-468	51.0	20.0	CH			
64	678-723	53.0	20.0	CH	19.1	1.60	
65	28-75	27.0	16.0	CL			
65	128-175	26.0	13.0	CL			
65	328-376	27.0	12.0	CL			
65	478-515	33.0	15.0	CL	14.8	1.60	5.2×10^{-6}
65	638-685	46.0	17.0	CL			
65	795-840	67.0	26.0	CH			
65	943-990	71.0	28.0	CH			
65	1093-1132	49.0	18.0	CL	22.5	1.38	2.8×10^{-6}
65	1238-1270	NP	NP	ML			
66	0-40	24.0	15.0	CL			
66	128-160	29.0	18.0	CL			
66	223-255	49.0	18.0	CL			
66	328-375	90.0	28.0	CH	41.9	1.18	1.3×10^{-9}
66	428-475	79.0	22.0	CH			
66	728-775	55.0	22.0	CH			
67	23-60	26.0	15.0	CL			
67	118-142	45.0	15.0	CL	17.7	1.67	1.2×10^{-7}
67	323-355	50.0	20.0	CH			
67	473-515	41.0	16.0	CL	25.9	1.57	5.2×10^{-7}
67	610-665	77.0	22.0	CH			
67	755-810	69.0	21.0	CH			
68	28-60	26.0	17.0	CL			
68	133-175	29.0	15.0	CL			
68	333-375	67.0	26.0	CH			
68	503-545	64.0	29.0	CH	30.0	1.35	
68	673-713	73.0	36.0	MH	34.7	1.31	1.2×10^{-5}
68	843-878	74.0	36.0	MH			
68	993-1018	58.0	27.0	CH	32.2	1.32	9.8×10^{-7}
68	1140-1158	52.0	29.0	MH			

(Continued)

Table 4. Physical Test Results

Boring No.	Sample Depth, cm	Atterberg Limits, Percent Water: Liquid Limit	Plastic Limit	USCS Classification	Water Content, %	Density, g/cc	Permeability, cm/sec
69	28-48	26.0	17.0	CL			
69	122-147	27.0	17.0	CL	14.1	1.83	
69	328-375	NP	NP	SM			
69	548-595	45.0	15.0	CL	21.0	1.70	5.5×10^{-9}
69	768-806	25.0	20.0	CL-ML			
69	988-1035	29.0	15.0	CL	27.2	1.55	1.7×10^{-8}
69	1280-1330	NP	NP	SP			
70	28-65	43.0	15.0	CL			
70	128-175	48.0	17.0	CL			
70	328-368	NP	NP	SM			
70	533-565	57.0	16.0	CH	20.4	1.73	0.0
70	738-780	28.0	13.0	CL			
70	935-974	NP	NP	SP-SM		1.55	3.0×10^{-5}
70	1235-1285	NP	NP	SP-SM			
71	28-65	36.0	15.0	CL			
71	120-138	NP	NP	SM			
71	328-375	NP	NP	SM			
71 (4)	543-590	43.0	14.0	CL	22.1	1.67	6.0×10^{-10}
71 (4)	572-580	NP	NP	SP-SM			
71	758-805	54.0	17.0	CH			
71	973-1010	61.0	27.0	CH			
71	1123-1170	NP	NP	SM			
71	1273-1320	34.0	14.0	CL	23.3	1.59	1.6×10^{-9}
71	1411-1448	NP	NP	SP-SM			
72	28-75	30.0	14.0	CL			
72	122-145	35.0	13.0	CL			
72	328-367	20.0	18.0	ML	14.6	1.62	
72	563-610	39.0	13.0	CL	17.5	1.78	1.2×10^{-8}
72	798-845	24.0	13.0	CL			
72	1033-1080	NP	NP	SM	11.2	1.59	4.6×10^{-4}
72	1320-1363	NP	NP	SP			
73	28-75	29.0	15.0	CL	9.6	1.71	
73	123-143	41.0	18.0	CL			
73	364-410	NP	NP	SM			
73	623-675	50.0	16.0	CH	26.3	1.56	3.9×10^{-9}
73	923-975	NP	NP	SM			
73	1225-1275	32.0	18.0	CL	29.5	1.50	4.5×10^{-7}
73	1520-1570	NP	NP	SM			
74	20-45	21.0	15.0	CL-ML			
74	125-160	87.0	34.0	CH			

(Continued)

Table 4. Physical Test Results

Boring No.	Sample Depth, cm	Atterberg Limits, Percent Water: Liquid Limit	Atterberg Limits, Percent Water: Plastic Limit	USCS Classification	Water Content, %	Density, g/cc	Permeability, cm/sec
74	328-360	36.0	14.0	CL			
74	658-705	26.0	17.0	CL	15.6	1.84	1.3×10^{-5}
74	988-1030	58.0	23.0	CH			
74	1318-1365	62.0	21.0	CH			
74	1468-1515	53.0	24.0	CH	31.5	1.46	7.0×10^{-8}
74	1618-1665	28.0	19.0	CL			
74	1918-1965	68.0	26.0	CH	28.1	1.44	
75	28-75	29.0	17.0	CL			
75	128-165	27.0	18.0	CL	10.6	1.75	
75	328-375	18.0	16.0	ML	13.9	1.71	7.6×10^{-5}
75	679-725	41.0	20.0	CL			
75	1028-1075	62.0	29.0	CH	36.1	1.29	9.0×10^{-7}
75	1378-1425	58.0	22.0	CH			
76	28-75	18.0	13.0	CL-ML			
76	128-175	40.0	14.0	CL			
76	328-375	18.0	17.0	ML			
76	628-675	58.0	19.0	CH	35.3	1.37	1.7×10^{-8}
76	928-975	43.0	24.0	CL	32.0	1.42	
76	1228-1275	72.0	33.0	CH	37.4	1.29	8.1×10^{-8}
77	28-75	28.0	17.0	CL			
77	128-175	31.0	14.0	CL			
77	328-368	63.0	22.0	CH	29.9	1.45	
77	528-575	72.0	28.0	CH	30.5	1.36	
77	728-775	50.0	21.0	CH	40.3	1.21	2.6×10^{-5}
77	928-975	66.0	30.0	CH	32.0	1.34	7.3×10^{-7}
78	28-75	35.0	15.0	CL			
78	128-175	59.0	19.0	CH			
78	328-365	47.0	21.0	CL	20.5	1.61	2.6×10^{-7}
78	528-575	33.0	18.0	CL			
78	728-775	57.0	25.0	CH	33.9	1.39	5.8×10^{-7}
78	928-975	43.0	22.0	CL			
78	1128-1170	57.0	21.0	CH			
78	1328-1375	67.0	30.0	CH			
79	19-61	14.0	13.0	ML	6.1	1.54	1.6×10^{-4}
79	133-175	NP	NP	SM			
79	233-275	NP	NP	SM			
79	333-375	NP	NP	ML			
79	433-475	NP	NP	ML	23.2	1.37	3.1×10^{-4}
79	725-760	NP	NP	SP-SM			

(Continued)

Table 4. Physical Test Results

Boring No.	Sample Depth, cm	Atterberg Limits, Percent Water: Liquid Limit	Atterberg Limits, Percent Water: Plastic Limit	USCS Classification	Water Content, %	Density, g/cc	Permeability, cm/sec
80	28-75	36.0	15.0	CL			
80	128-175	31.0	16.0	CL	14.5	1.76	1.3×10^{-5}
80	228-275	30.0	21.0	CL	22.8	1.60	3.4×10^{-6}
80	328-375	39.0	23.0	CL			
80	428-475	39.0	19.0	CL			
80	578-625	36.0	23.0	CL			
81	28-75	41.0	20.0	CL			
81	128-160	30.0	19.0	CL			
81	320-345	29.0	16.0	CL	14.5	1.78	
81	503-550	56.0	21.0	CH	38.5	1.29	4.8×10^{-7}
81	678-725	46.0	23.0	CL	39.5	1.25	2.7×10^{-7}
81	853-887	45.0	28.0	ML	32.6	1.32	
82	20-60	26.0	19.0	CL-ML			
82	128-175	68.0	29.0	CH	24.0	1.41	
82	228-260	47.0	20.0	CL	22.2	1.53	
82	328-375	49.0	19.0	CL	32.8	1.34	1.7×10^{-6}
82	628-675	64.0	30.0	CH	39.2	1.26	10.0×10^{-6}
83	28-75	22.0	18.0	CL-ML			
83	128-175	26.0	16.0	CL			
83	328-375	57.0	22.0	CH			
83	468-515	72.0	25.0	CH	35.7	1.34	6.2×10^{-5}
83	608-655	44.0	18.0	CL	33.2	1.35	3.0×10^{-6}
83	748-795	57.0	28.0	CH	30.2	1.36	
83	1040-1110	55.0	21.0	CH			
84	20-45	NP	NP	ML			
84	128-155	21.0	15.0	CL-ML			
84	328-375	42.0	16.0	CL	22.3	1.48	
84	518-565	NP	NP	SM	25.8	1.48	1.7×10^{-4}
84	810-830	NP	NP	SP			
85	28-75	49.0	19.0	CL			
85	128-170	33.0	20.0	CL	12.0	1.73	
85	328-375	26.0	21.0	CL-ML	17.5	1.65	
85	478-515	NP	NP	SM		1.45	5.9×10^{-4}
85	795-865	43.0	18.0	CL	26.1	1.54	7.8×10^{-7}
86	28-75	28.0	14.0	CL	14.7	1.69	
86	128-175	36.0	13.0	CL	19.0	1.75	
86	428-470	36.0	14.0	CL	16.6	1.66	9.5×10^{-5}
86	728-775	77.0	30.0	CH	43.7	1.20	1.4×10^{-7}
87	15-75	32.0	15.0	CL	13.8	1.59	1.4×10^{-4}
87	128-153	59.0	26.0	CH	25.3	1.43	

(Continued)

Table 4. Physical Test Results

Boring No.	Sample Depth, cm	Atterberg Limits, Percent Water: Liquid Limit	Atterberg Limits, Percent Water: Plastic Limit	USCS Classification	Water Content, %	Density, g/cc	Permeability, cm/sec
87	328-356	69.0	31.0	CH	44.1	1.22	
87	428-470	58.0	29.0	CH	38.1	1.30	9.7×10^{-7}
87	528-560	52.0	22.0	CH	32.3	1.40	
87	728-760	NP	NP	ML	35.6	1.32	
88	28-75	31.0	13.0	CL			
88	128-175	43.0	15.0	CL			
88	360-375	56.0	20.0	CH	24.2	1.42	1.2×10^{-6}
88	425-465	48.0	32.0	ML	19.1	1.60	
88	525-550	61.0	32.0	MH			
88	828-875	50.0	39.0	MH	41.0	1.23	3.0×10^{-5}
89	28-75	NP	NP	ML			
89	160-175	32.0	16.0	CL	17.0	1.67	3.5×10^{-5}
89	328-375	54.0	21.0	CH			
89	428-469	54.0	29.0	CH			
89	628-654	48.0	21.0	CL	28.7	1.46	7.0×10^{-7}
90	28-75	27.0	16.0	CL			
90	120-150	43.0	15.0	CL	16.3	1.61	7.5×10^{-8}
90	328-375	49.0	31.0	CL			
90	460-475	40.0	29.0	ML	29.3	1.40	4.3×10^{-7}
91	28-75	23.0	19.0	CL-ML			
91	128-175	28.0	17.0	CL	17.1	1.48	1.4×10^{-6}
91	335-360	NP	NP	SM	15.9	1.61	6.9×10^{-10}
91	420-442	NP	NP	SM			
91	528-575	51.0	17.0	CH	22.5	1.50	0.3×10^{-6}
91	828-875	42.0	20.0	CL	26.5	1.54	0.4×10^{-6}
92	28-75	19.0	17.0	ML			
92	128-160	24.0	17.0	CL			
92	225-247	30.0	20.0	CL			
92	358-405	35.0	26.0	ML	26.3	1.50	3.3×10^{-6}
92	628-675	50.0	25.0	CH	31.1	1.43	2.5×10^{-6}
93	20-75	25.0	16.0	CL			
93	128-175	48.0	19.0	CL	11.0	1.76	8.0×10^{-7}
93	328-375	27.0	15.0	CL			
93	430-465	21.0	15.0	CL-ML			
93	578-620	NP	NP	SM	13.0	1.73	3.6×10^{-5}
93	878-925	NP	NP	ML			
94	28-60	39.0	17.0	SC			
94	128-175	64.0	31.0	CH	33.8	1.36	2.9×10^{-6}
94	223-275	73.0	31.0	CH			

(Continued)

Table 4. Physical Test Results

Boring No.	Sample Depth, cm	Atterberg Limits, Percent Water: Liquid Limit	Atterberg Limits, Percent Water: Plastic Limit	USCS Classification	Water Content, %	Density, g/cc	Permeability, cm/sec
94	328-375	73.0	29.0	CH	37.6	1.28	2.1×10^{-6}
94	628-667	77.0	28.0	CH			
95	28-75	NP	NP	SC			
95	120-127	35.0	29.0	ML			
95	228-275	67.0	32.0	CH	41.9	1.24	
95	328-375	51.0	28.0	CH	36.9	1.34	2.1×10^{-8}
95	630-650	36.0	34.0	ML			
96	28-75	NP	NP	SM			
96	128-175	NP	NP	SM	18.0	1.75	3.5×10^{-5}
96	225-275	NP	NP	SM			
96	528-575	64.0	23.0	CH	37.0	1.32	
97	28-75	37.0	15.0	CL			
97	128-175	33.0	17.0	CL			
97	228-275	27.0	20.0	CL			
97	328-355	55.0	19.0	CH			
97	428-475	51.0	19.0	CH	22.8	1.55	1.5×10^{-9}
97	578-625	24.0	13.0	CL			
97	678-703	NP	NP	SM			
97	778-813	NP	NP	ML	25.4	1.61	2.9×10^{-6}
97	1065-1090	NP	NP	SP			
98	28-75	22.0	15.0	CL			
98	128-175	32.0	15.0	CL	21.6	1.62	8.3×10^{-7}
98	228-275	27.0	17.0	CL			
98	323-358	26.0	18.0	SC			
98	578-625	36.0	18.0	CL	11.8	1.64	2.17×10^{-5}
99	28-75	21.0	17.0	CL-ML			
99	128-175	25.0	15.0	CL			
99	226-275	29.0	16.0	CL			
99	328-370	30.0	14.0	SC			
99	428-470	NP	NP	SP-SM	8.2	1.61	2.87×10^{-5}
99	528-575	NP	NP	SM			
99	628-675	NP	NP	SM			
99	920-952	NP	NP	SM			
100	20-66	38.0	15.0	CL	20.0	1.57	3.93×10^{-6}
100	120-145	74.0	23.0	CH			
100	225-263	87.0	28.0	CH			
100	310-335	NP	NP	ML			
100	433-475	27.0	14.0	CL			
100	528-575	24.0	18.0	SC-SM	20.5	1.72	1.48×10^{-5}
100	813-838	NP	NP	SP-SM			

(Continued)

Table 4. Physical Test Results

Boring No.	Sample Depth, cm	Atterberg Limits, Percent Water: Liquid Limit	Atterberg Limits, Percent Water: Plastic Limit	USCS Classification	Water Content, %	Density, g/cc	Permeability, cm/sec
101	28-75	33.0	17.0	CL			
101	118-172	NP	NP	ML			
101	228-275	NP	NP	ML			
101	328-375	27.0	22.0	CL-ML	6.4	1.45	1.21×10^{-4}
101	470-495	NP	NP	SM			
101	620-675	24.0	22.0	ML	21.6	1.65	1.00×10^{-5}
101	915-940	NP	NP	SP			
102	28-75	37.0	18.0	CL	4.5	1.53	1.13×10^{-4}
102	110-140	44.0	20.0	CL			
102	323-375	NP	NP	SM	30.5	1.49	1.22×10^{-5}
102	420-440	NP	NP	ML			
102	715-755	NP	NP	SM			
103	28-60	NP	NP	ML			
103	128-175	48.0	19.0	CL			
103	228-260	38.0	18.0	CL	11.0	1.51	1.13×10^{-4}
103	330-360	24.0	25.0	ML	19.5	1.51	5.31×10^{-5}
103	620-675	NP	NP	SP			
104	28-75	NP	NP	ML			
104	128-158	51.0	19.0	CH			
104	228-258	NP	NP	ML	18.7	1.52	4.12×10^{-4}
104	328-375	NP	NP	SM	23.4	1.62	4.75×10^{-4}
104	620-650	21.0	16.0	CL-ML			
105	28-75	18.0	17.0	ML			
105	128-175	NP	NP	SM			
105	228-275	27.0	16.0	SC		1.65	5.44×10^{-7}
105	328-375	28.0	20.0	SC			
105	428-475	NP	NP	SP-SM		1.51	6.34×10^{-5}
105	748-795	NP	NP	SP-SM			
106	28-63	24.0	14.0	SC			
106	123-160	27.0	16.0	SC			
106	325-355	30.0	22.0	CL			
106	475-510	NP	NP	SM			
106	628-660	34.0	26.0	ML			
106	725-750	37.0	23.0	CL			
106	1028-1075	NP	NP	SM		1.47	5.66×10^{-4}
107	23-55	17.0	17.0	ML			
107	128-175	23.0	17.0	CL-ML		1.72	2.26×10^{-4}
107	328-375	26.0	24.0	SM			
107	493-540	42.0	18.0	SC		1.30	2.74×10^{-5}

(Continued)

Table 4. Physical Test Results

Boring No.	Sample Depth, cm	Atterberg Limits, Percent Water: Liquid Limit	Atterberg Limits, Percent Water: Plastic Limit	USCS Classification	Water Content, %	Density, g/cc	Permeability, cm/sec
107	658-701	NP	NP	SM			
107	823-870	34.0	24.0	CL			
107	978-1025	NP	NP	SM			
107	1178-1215	NP	NP	SM			
108	0-70	20.0	17.0	ML			
108	174-198	39.0	14.0	CL			
108	329-366	23.0	14.0	CL			
108	478-500	38.0	14.0	CL			
108	628-664	24.0	14.0	CL			
108	783-811	36.0	13.0	CL			
108	930-966	27.0	16.0	CL			3.68×10^{-7}
108	1079-1088	NP	NP	SM			
108	1228-1253	NP	NP	SM			
108	1381-1411	NP	NP	SM			
108	1524-1539	NP	NP	SM			
108	1652-1695	NP	NP	SP			
108	1798-1844	NP	NP	SP-SM			
108	1946-1993	NP	NP	SM			
108	2100-2146	NP	NP	SM			
108	2280-2316	87.0	24.0	CH			
108	2429-2448	45.0	22.0	CL			
108	2551-2579	NP	NP	SP-SM			
108	2700-2728	47.0	20.0	CL			
108	2850-2896	NP	NP	SM			
108	3170-3191	NP	NP	SP-SM			
108	3331-3374	42.0	16.0	CL			
108	3472-3520	44.0	16.0	CL			
108	3630-3670	60.0	23.0	CH		1.48	1.68×10^{-6}
108	3780-3816	75.0	30.0	CH			
108	3932-3968	44.0	18.0	CL			
109	30-70	26.0	18.0	CL			
109	162-174	25.0	17.0	CL			
109	344-369	NP	NP	SM			
109	631-668	48.0	15.0	CL			
109	930-948	27.0	17.0	CL			
109	1231-1268	19.0	16.0	ML		1.69	4.65×10^{-7}
109	1500-1545	NP	NP	SM			
109	1810-1826	NP	NP	SM			
109	2100-2121	41.0	21.0	CL			

(Continued)

Table 4. Physical Test Results

Boring No.	Sample Depth, cm	Atterberg Limits, Percent Water: Liquid Limit	Atterberg Limits, Percent Water: Plastic Limit	USCS Classification	Water Content, %	Density, g/cc	Permeability, cm/sec
109	2722-2743	50.2	24.4	CH			
109	2999-3005	36.0	26.0	ML			
109	3612-3636	43.0	36.0	ML			
109	4221-4267	71.0	30.0	CH		1.25	4.97×10^{-7}
110	21-70	44.0	19.0	CL			
110	171-198	35.0	14.0	CL		1.77	2.01×10^{-6}
110	320-366	23.0	17.0	CL-ML			
110	622-658	35.0	13.0	CL			
110	920-957	NP	NP	SM			
110	1231-1268	NP	NP	ML			
110	1521-1567	NP	NP	SM		1.70	5.89×10^{-4}
110	1829-1865	NP	NP	SM			
110	2121-2152	20.0	10.0	CL			
110	2429-2463	NP	NP	SM			
110	2880-2908	61.0	30.0	CH		1.37	6.07×10^{-7}
110	3018-3045	41.0	25.0	CL			
111	21-70	36.0	16.0	CL			
111	171-189	40.0	18.0	CL			
111	320-354	39.0	14.0	CL			
111	622-649	70.0	19.0	CH		1.48	2.12×10^{-8}
111	920-957	22.0	19.0	ML			
111	1231-1262	NP	NP	SM			
111	1521-1576	NP	NP	SM		1.51	5.93×10^{-4}
111	1820-1856	NP	NP	SP-SM			
111	2121-2167	NP	NP	ML			
111	2420-2435	NP	NP	SM			
111	2774-2822	60 0	30.0	CH			
111	3020-3060	50.0	18.0	CH			
111	3322-3347	46.0	31.0	ML			1.0339×10^{-7}
111	3609-3618	40.0	23.0	CL			
111	3923-3972	43.0	19.0	CL			
111	4221-4264	31.0	23.0	ML			
111	4831-4868	38.0	27.0	ML			
111	5124-5172	85.0	35.0	CH			$.481 \times 10^{-6}$

Table 5

Water Table Elevations

Boring No.	Water Table Elevation, cms	
	24 Jun - 29 Jul 1977	2 - 4 Aug 1977
1	6097	6133
2	No Piezometer	
3	6098	6090
4	6116	6108
5	6074	6027
6	6411	6366
7	6047	6118
8	6020	6012
9	6035	6018
10	6107	6102
11	6052	6045
12	6052	6055
13	6107	6100
14	6202	6118
15	6111	6105
16	*	6107
17	6116	6095
18	6104	6096
19	6121	6106
20	6120	6109
21	6113	6105
22	6044	6106
23	6034	6042
24	6051	6052
25	6041	6043
26	6035	6025
27	6075	6043
28	6954	6892
29	7017	7015
30	6131	6127
31	5928	5933
32	6098	6091
33	6080	6071
34	6085	6036
35	6112	6104
36	6064	6058
37	6170	6168
38	6142	6134
39	6636	6735
40	6145	6148
41	6139	6138
42	6224	6138

* No Data

(Continued)

Table 5

Water Table Elevations

Boring No.	Water Table Elevation, cms 24 Jun - 29 Jul 1977	2 - 4 Aug 1977
43	7582	7574
44	7568	7564
45	8016	8033
46	8146	8141
47	7566	7838
48	6123	6108
49	6037	6003
50	6066	6051
51	6053	6015
52	6076	6007
53	7853	7792
54	6057	6051
55	6106	6014
56	6026	6018
57	6133	6125
58	6161	6149
59	6183	6173
60	6254	6232
61	6180	6176
62	7813	7799
63	7464	7480
64	7310	7312
65	6913	7014
66	8021	8018
67	8288	8282
68	8435	8433
69	6185	6183
70	6115	6112
71	*	6117
72	6112	6109
73	6181	6179
74	6643	6731
75	7156	7152
76	7276	7273
77	7445	7443
78	8038	7935
79	6057	6068
80	7484	7490
81	7394	7408
82	7987	7986

* No Data

(Continued)

Table 5

Water Table Elevations

Boring No.	Water Table Elevation, cms	
	24 Jun - 29 Jul 1977	2 - 4 Aug 1977
83	8308	8308
84	9095	9105
85	8886	9223
86	9029	9623
87	9524	9519
88	9031	9030
89	8072	8065
90	8764	8747
91	9062	9062
92	7976	7978
93	7598	7596
94	7116	7108
95	7415	7514
96	6389	6389
97	6086	6082
98	6297	6298
99	*	6093
100	6035	6036
101	6029	5787
102	5995	5979
103	5992	5981
104	5984	5972
105	7621	7620
106	7639	7637
107	7636	7635

* No Data

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APPENDIX A

WELL INSTALLATION AND WATER LEVEL DATA

One hundred and six of the PBA borings were developed as groundwater monitoring wells. The data applicable to each well and the groundwater measurements made during the study are presented in the following tabulation. Keys to the computer-retrieved data are:

ENTRY	EXPLANATION
BOREHOLE NO	Boring Number
FD INT MEAS	Field Drilling File, Interval Measured
FD INT VALUE CM	Field Drilling File, Interval Value, centimeters
WE001	Waterways Experiment Station Boring 001
STKUP	Stick Up, PVC pipe above ground level
67.00	Measured Value
FD INT DEPTH CM	Field Drilling File, Interval Depth, centimeters
FD INT THICK CM	Field Drilling File, Interval Thickness, centimeters
SFILT	Sand Filter, sand emplaced around well screen
SCREN	Screen, slotted PVC pipe
GROUT	Grout, water-cement-bentonite mixture placed from the top of the sand filter to the ground surface
WELL NO	Groundwater monitoring well number
GW STAB DEPTH CM	Groundwater Stabilized Depth, centimeters
GW STAB DATE	Groundwater Stabilized Date; day the measurement was made
08/03/1977	Date (month, day, year)

*	BORE HOLE NO	FD INT MEAS	FD INT VALUE CM
***			
*	WE001	STKUP	67.00
*	WE003	STKUP	30.00
*	WE004	STKUP	30.00
*	WE005	STKUP	100.00
*	WE006	STKUP	100.00
*	WE007	STKUP	100.00
*	WE008	STKUP	150.00
*	WE009	STKUP	100.00
*	WE010	STKUP	90.00
*	WE011	STKUP	155.00
*	WE012	STKUP	150.00
*	WE013	STKUP	100.00
*	WE014	STKUP	100.00
*	WE015	STKUP	100.00
*	WE016	STKUP	100.00
*	WE017	STKUP	100.00
*	WE018	STKUP	91.00
*	WE019	STKUP	95.00
*	WE020	STKUP	100.00
*	WE021	STKUP	100.00
*	WE022	STKUP	100.00
*	WE023	STKUP	105.00
*	WE024	STKUP	100.00
*	WE025	STKUP	100.00
*	WE026	STKUP	100.00
*	WE027	STKUP	100.00
*	WE028	STKUP	100.00
*	WE029	STKUP	100.00
*	WE030	STKUP	100.00
*	WE031	STKUP	100.00
*	WE032	STKUP	100.00
*	WE033	STKUP	100.00
*	WE034	STKUP	100.00
*	WE035	STKUP	100.00
*	WE036	STKUP	100.00
*	WE037	STKUP	100.00
*	WE038	STKUP	100.00
*	WE039	STKUP	100.00
*	WE040	STKUP	100.00
*	WE041	STKUP	100.00
*	WE042	STKUP	100.00
*	WE043	STKUP	100.00
*	WE044	STKUP	100.00
*	WE045	STKUP	100.00
*	WE046	STKUP	100.00
*	WE047	STKUP	100.00
*	WE048	STKUP	100.00
*	WE049	STKUP	100.00
*	WE050	STKUP	100.00
*	WE051	STKUP	100.00
*	WE052	STKUP	100.00
*	WE053	STKUP	100.00
*	WE054	STKUP	100.00

WORKING DRAFT

	BORE HOLE NO	FD INT MEAS	FD INT VALUE CM
*	WE055	STKUP	100.00
*	WE056	STKUP	100.00
*	WE057	STKUP	100.00
*	WE058	STKUP	100.00
*	WE059	STKUP	100.00
*	WE060	STKUP	100.00
*	WE061	STKUP	100.00
*	WE062	STKUP	100.00
*	WE063	STKUP	85.00
*	WE064	STKUP	100.00
*	WE065	STKUP	100.00
*	WE066	STKUP	100.00
*	WE067	STKUP	100.00
*	WE068	STKUP	100.00
*	WE069	STKUP	100.00
*	WE070	STKUP	100.00
*	WE071	STKUP	100.00
*	WE072	STKUP	82.00
*	WE073	STKUP	100.00
*	WE074	STKUP	100.00
*	WE075	STKUP	100.00
*	WE076	STKUP	100.00
*	WE077	STKUP	100.00
*	WE078	STKUP	100.00
*	WE079	STKUP	100.00
*	WE080	STKUP	100.00
*	WE081	STKUP	100.00
*	WE082	STKUP	100.00
*	WE083	STKUP	100.00
*	WE084	STKUP	100.00
*	WE085	STKUP	100.00
*	WE086	STKUP	100.00
*	WE087	STKUP	100.00
*	WE088	STKUP	100.00
*	WE089	STKUP	100.00
*	WE090	STKUP	100.00
*	WE091	STKUP	100.00
*	WE092	STKUP	100.00
*	WE093	STKUP	100.00
*	WE094	STKUP	100.00
*	WE095	STKUP	100.00
*	WE096	STKUP	150.00
*	WE097	STKUP	100.00
*	WE098	STKUP	100.00
*	WE099	STKUP	100.00
*	WE100	STKUP	100.00
*	WE101	STKUP	100.00
*	WE102	STKUP	100.00
*	WE103	STKUP	100.00
*	WE104	STKUP	150.00
*	WE105	STKUP	100.00
*	WE106	STKUP	100.00
*	WE107	STKUP	100.00

*	BORE HOLE NO	FD INT MEAS	FD INT DEPTH CM	FD INT THICK CM
***				
*	WE001	SFILT	1006	299
*	WE003	SFILT	1160	1390
*	WE004	SFILT	1065	800
*	WE005	SFILT	40	460
*	WE006	SFILT	150	405
*	WE007	SFILT	900	825
*	WE008	SFILT	300	500
*	WE009	SFILT	475	532
*	WE010	SFILT	1050	555
*	WE011	SFILT	250	634
*	WE012	SFILT	1050	588
*	WE013	SFILT	1125	645
*	WE014	SFILT	915	915
*	WE015	SFILT	1050	596
*	WE016	SFILT	800	520
*	WE017	SFILT	1000	635
*	WE018	SFILT	1050	748
*	WE019	SFILT	1200	590
*	WE020	SFILT	1150	530
*	WE021	SFILT	1050	550
*	WE022	SFILT	1100	612
*	WE023	SFILT	1200	476
*	WE024	SFILT	1300	628
*	WE025	SFILT	1250	435
*	WE026	SFILT	1150	628
*	WE027	SFILT	850	969
*	WE028	SFILT	900	707
*	WE029	SFILT	825	497
*	WE030	SFILT	914	1012
*	WE031	SFILT	100	366
*	WE032	SFILT	610	863
*	WE033	SFILT	200	475
*	WE034	SFILT	725	584
*	WE035	SFILT	840	600
*	WE036	SFILT	975	505
*	WE037	SFILT	609	1077
*	WE038	SFILT	675	635
*	WE039	SFILT	950	592
*	WE040	SFILT	1050	718
*	WE041	SFILT	850	560
*	WE042	SFILT	950	600
*	WE043	SFILT	775	575
*	WE044	SFILT	600	465
*	WE045	SFILT	450	950
*	WE046	SFILT	750	525
*	WE047	SFILT	150	392
*	WE048	SFILT	550	605
*	WE049	SFILT	525	481
*	WE050	SFILT	300	475
*	WE051	SFILT	550	415
*	WE052	SFILT	425	580
*	WE053	SFILT	450	520
*	WE054	SFILT	750	495

WORKING DRAFT

	BORE HOLE NO	FD INT MEAS	FD INT DEPTH CM	FD INT THICK CM
*	WE055	SFILT	700	500
*	WE056	SFILT	625	545
*	WE057	SFILT	625	470
*	WE058	SFILT	600	428
*	WE059	SFILT	650	505
*	WE060	SFILT	200	572
*	WE061	SFILT	1100	550
*	WE062	SFILT	150	655
*	WE063	SFILT	175	500
*	WE064	SFILT	300	423
*	WE065	SFILT	650	620
*	WE066	SFILT	300	475
*	WE067	SFILT	325	485
*	WE068	SFILT	300	858
*	WE069	SFILT	875	455
*	WE070	SFILT	825	540
*	WE071	SFILT	875	573
*	WE072	SFILT	925	550
*	WE073	SFILT	1100	520
*	WE074	SFILT	1250	715
*	WE075	SFILT	1000	425
*	WE076	SFILT	400	875
*	WE077	SFILT	550	425
*	WE078	SFILT	900	475
*	WE079	SFILT	250	525
*	WE080	SFILT	250	405
*	WE081	SFILT	425	475
*	WE082	SFILT	200	475
*	WE083	SFILT	550	565
*	WE084	SFILT	215	615
*	WE084	SFILT	150	65
*	WE085	SFILT	350	520
*	WE086	SFILT	200	575
*	WE087	SFILT	300	475
*	WE088	SFILT	500	375
*	WE089	SFILT	250	404
*	WE090	SFILT	275	434
*	WE091	SFILT	350	525
*	WE092	SFILT	250	425
*	WE093	SFILT	475	450
*	WE094	SFILT	250	425
*	WE095	SFILT	275	381
*	WE096	SFILT	150	425
*	WE097	SFILT	600	550
*	WE098	SFILT	225	395
*	WE099	SFILT	400	552
*	WE100	SFILT	450	388
*	WE101	SFILT	350	590
*	WE102	SFILT	300	455
*	WE103	SFILT	300	400
*	WE104	SFILT	225	450
*	WE105	SFILT	325	470
*	WE106	SFILT	600	475
*	WE107	SFILT	700	515

WORKING DRAFT

*	BORE HOLE NO	FD INT MEAS	FD INT DEPTH CM	FD INT THICK CM
***				
*	WE001	SCREN	1155	137
*	WE003	SCREN	1350	125
*	WE004	SCREN	1280	130
*	WE005	SCREN	60	195
*	WE006	SCREN	280	135
*	WE007	SCREN	1350	130
*	WE008	SCREN	424	130
*	WE009	SCREN	625	137
*	WE010	SCREN	1250	130
*	WE011	SCREN	405	130
*	WE012	SCREN	1210	135
*	WE013	SCREN	1275	135
*	WE014	SCREN	1365	130
*	WE015	SCREN	1200	130
*	WE016	SCREN	900	130
*	WE017	SCREN	1155	135
*	WE018	SCREN	1325	135
*	WE019	SCREN	1350	140
*	WE020	SCREN	1305	125
*	WE021	SCREN	1200	135
*	WE022	SCREN	1250	130
*	WE023	SCREN	1345	135
*	WE024	SCREN	1460	130
*	WE025	SCREN	1400	135
*	WE026	SCREN	1300	130
*	WE027	SCREN	1300	130
*	WE028	SCREN	1040	130
*	WE029	SCREN	975	135
*	WE030	SCREN	1440	130
*	WE031	SCREN	150	125
*	WE032	SCREN	1050	125
*	WE033	SCREN	350	125
*	WE034	SCREN	875	135
*	WE035	SCREN	990	130
*	WE036	SCREN	1025	125
*	WE037	SCREN	1025	140
*	WE038	SCREN	825	125
*	WE039	SCREN	1150	130
*	WE040	SCREN	1200	130
*	WE041	SCREN	1000	125
*	WE042	SCREN	1175	135
*	WE043	SCREN	925	135
*	WE044	SCREN	700	125
*	WE045	SCREN	500	135
*	WE046	SCREN	800	135
*	WE047	SCREN	200	130
*	WE048	SCREN	650	135
*	WE049	SCREN	625	125
*	WE050	SCREN	400	130
*	WE051	SCREN	650	130
*	WE052	SCREN	575	135
*	WE053	SCREN	550	135

	BORE HOLE NO	FD INT MEAS	FD INT DEPTH CM	FD INT THICK CM
*	WE054	SCREN	850	130
*	WE055	SCREN	800	135
*	WE056	SCREN	725	130
*	WE057	SCREN	725	130
*	WE058	SCREN	700	130
*	WE059	SCREN	750	130
*	WE060	SCREN	300	135
*	WE061	SCREN	1200	135
*	WE062	SCREN	200	130
*	WE063	SCREN	225	130
*	WE064	SCREN	350	130
*	WE065	SCREN	750	135
*	WE066	SCREN	375	140
*	WE067	SCREN	425	130
*	WE068	SCREN	400	135
*	WE069	SCREN	975	135
*	WE070	SCREN	925	140
*	WE071	SCREN	975	130
*	WE072	SCREN	996	135
*	WE073	SCREN	1200	135
*	WE074	SCREN	1350	130
*	WE075	SCREN	1100	125
*	WE076	SCREN	500	135
*	WE077	SCREN	650	135
*	WE078	SCREN	1000	135
*	WE079	SCREN	350	135
*	WE080	SCREN	350	135
*	WE081	SCREN	525	135
*	WE082	SCREN	275	130
*	WE083	SCREN	650	130
*	WE084	SCREN	200	130
*	WE085	SCREN	450	135
*	WE086	SCREN	275	140
*	WE087	SCREN	400	140
*	WE088	SCREN	550	130
*	WE089	SCREN	300	145
*	WE090	SCREN	350	135
*	WE091	SCREN	475	140
*	WE092	SCREN	300	135
*	WE093	SCREN	575	130
*	WE094	SCREN	300	140
*	WE095	SCREN	325	130
*	WE096	SCREN	200	130
*	WE097	SCREN	750	135
*	WE098	SCREN	275	135
*	WE099	SCREN	550	140
*	WE100	SCREN	450	135
*	WE101	SCREN	450	130
*	WE102	SCREN	350	135
*	WE103	SCREN	375	130
*	WE104	SCREN	275	135
*	WE105	SCREN	425	140
*	WE106	SCREN	700	130
*	WE107	SCREN	800	135

*	BORE HOLE NO	FD INT MEAS	FD INT DEPTH CM	FD INT THICK CM
***				
*	WE001	GROUT	0	1006
*	WE003	GROUT	0	1160
*	WE004	GROUT	0	1065
*	WE005	GROUT	0	40
*	WE006	GROUT	0	150
*	WE007	GROUT	0	900
*	WE008	GROUT	0	300
*	WE009	GROUT	0	475
*	WE010	GROUT	0	1050
*	WE011	GROUT	0	250
*	WE012	GROUT	0	1050
*	WE013	GROUT	0	1125
*	WE014	GROUT	0	915
*	WE015	GROUT	0	1050
*	WE016	GROUT	0	800
*	WE017	GROUT	0	1000
*	WE018	GROUT	0	1050
*	WE019	GROUT	0	1200
*	WE020	GROUT	0	1150
*	WE021	GROUT	0	1050
*	WE022	GROUT	0	1100
*	WE023	GROUT	0	1200
*	WE024	GROUT	0	1300
*	WE025	GROUT	0	1250
*	WE026	GROUT	0	1150
*	WE027	GROUT	0	850
*	WE028	GROUT	0	900
*	WE029	GROUT	0	825
*	WE030	GROUT	0	914
*	WE031	GROUT	0	100
*	WE032	GROUT	0	610
*	WE033	GROUT	0	200
*	WE034	GROUT	0	725
*	WE035	GROUT	0	840
*	WE036	GROUT	0	975
*	WE037	GROUT	0	609
*	WE038	GROUT	0	675
*	WE039	GROUT	0	950
*	WE040	GROUT	0	1050
*	WE041	GROUT	0	850
*	WE042	GROUT	0	950
*	WE043	GROUT	0	775
*	WE044	GROUT	0	600
*	WE045	GROUT	0	450
*	WE046	GROUT	0	750
*	WE047	GROUT	0	150
*	WE048	GROUT	0	550
*	WE049	GROUT	0	525
*	WE050	GROUT	0	300
*	WE051	GROUT	0	550
*	WE052	GROUT	0	425
*	WE053	GROUT	0	450
*	WE054	GROUT	0	750

	BORE HOLE NO	FD INT MEAS	FD INT DEPTH CM	FD INT THICK CM
*	WE055	GROUT	0	700
*	WE056	GROUT	0	625
*	WE057	GROUT	0	625
*	WE058	GROUT	0	600
*	WE059	GROUT	0	650
*	WE060	GROUT	0	200
*	WE061	GROUT	0	1100
*	WE062	GROUT	0	150
*	WE063	GROUT	0	175
*	WE064	GROUT	0	300
*	WE065	GROUT	0	650
*	WE066	GROUT	0	300
*	WE067	GROUT	0	325
*	WE068	GROUT	0	300
*	WE069	GROUT	0	875
*	WE070	GROUT	0	825
*	WE071	GROUT	0	875
*	WE072	GROUT	0	925
*	WE073	GROUT	0	1100
*	WE074	GROUT	0	1250
*	WE075	GROUT	0	1000
*	WE076	GROUT	0	400
*	WE077	GROUT	0	550
*	WE078	GROUT	0	900
*	WE079	GROUT	0	250
*	WE080	GROUT	0	250
*	WE081	GROUT	0	425
*	WE082	GROUT	0	200
*	WE083	GROUT	0	550
*	WE084	GROUT	0	150
*	WE085	GROUT	0	350
*	WE086	GROUT	0	200
*	WE087	GROUT	0	300
*	WE088	GROUT	0	500
*	WE089	GROUT	0	250
*	WE090	GROUT	0	275
*	WE091	GROUT	0	350
*	WE092	GROUT	0	250
*	WE093	GROUT	0	475
*	WE094	GROUT	0	250
*	WE095	GROUT	0	275
*	WE096	GROUT	0	150
*	WE097	GROUT	0	600
*	WE098	GROUT	0	225
*	WE099	GROUT	0	400
*	WE100	GROUT	0	450
*	WE101	GROUT	0	350
*	WE102	GROUT	0	300
*	WE103	GROUT	0	300
*	WE104	GROUT	0	225
*	WE105	GROUT	0	325
*	WE106	GROUT	0	600
*	WE107	GROUT	0	700

*	WELL NO	GW STAB DEPTH CM	GW STAB DATE
***			
*	WE001	1131	08/03/1977
*	WE002	1313	08/03/1977
*	WE003	1316	08/03/1977
*	WE004	1268	08/03/1977
*	WE005	77	08/03/1977
*	WE006	238	08/03/1977
*	WE007	1263	08/03/1977
*	WE008	428	08/03/1977
*	WE009	580	08/03/1977
*	WE010	1232	08/03/1977
*	WE011	393	08/03/1977
*	WE012	1230	08/03/1977
*	WE013	1264	08/02/1977
*	WE014	1338	08/03/1977
*	WE015	1184	08/02/1977
*	WE016	868	08/03/1977
*	WE017	1179	08/03/1977
*	WE018	1327	08/03/1977
*	WE019	1350	08/03/1977
*	WE020	1294	08/03/1977
*	WE021	1199	08/03/1977
*	WE022	1174	08/03/1977
*	WE023	1358	08/03/1977
*	WE024	1450	08/03/1977
*	WE025	1415	08/03/1977
*	WE026	1329	08/03/1977
*	WE027	1438	08/03/1977
*	WE028	698	08/03/1977
*	WE029	793	08/03/1977
*	WE030	1437	08/03/1977
*	WE031	262	08/04/1977
*	WE032	1048	08/02/1977
*	WE033	328	08/02/1977
*	WE034	907	08/02/1977
*	WE035	956	08/03/1977
*	WE036	1017	08/02/1977
*	WE037	966	08/03/1977
*	WE038	833	08/02/1977
*	WE039	510	08/03/1977
*	WE040	1168	08/03/1977
*	WE041	992	08/03/1977
*	WE042	1094	08/03/1977
*	WE043	422	08/03/1977
*	WE044	512	08/03/1977
*	WE045	292	08/03/1977
*	WE046	368	08/02/1977
*	WE047	87	08/02/1977
*	WE048	596	08/02/1977
*	WE049	624	08/03/1977
*	WE050	442	08/03/1977
*	WE051	439	08/03/1977
*	WE052	644	08/03/1977
*	WE053	314	08/03/1977
*	WE054	376	08/02/1977

WORKING DRAFT

*	WELL NO	GW STAB DEPTH GM	GW STAB DATE
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*	WE001	1131	08/03/1977
*	WE002	1318	08/03/1977
*	WE003	1318	08/03/1977
*	WE004	1268	08/03/1977
*	WE005	77	08/03/1977
*	WE006	258	08/03/1977
*	WE007	1263	08/03/1977
*	WE008	428	08/03/1977
*	WE009	580	08/03/1977
*	WE010	1232	08/03/1977
*	WE011	393	08/03/1977
*	WE012	1230	08/03/1977
*	WE013	1264	08/02/1977
*	WE014	1338	08/03/1977
*	WE015	1184	08/02/1977
*	WE016	888	08/03/1977
*	WE017	1179	08/03/1977
*	WE018	1327	08/03/1977
*	WE019	1350	08/03/1977
*	WE020	1294	08/03/1977
*	WE021	1199	08/03/1977
*	WE022	1174	08/03/1977
*	WE023	1358	08/03/1977
*	WE024	1450	08/03/1977
*	WE025	1415	08/03/1977
*	WE026	1329	08/03/1977
*	WE027	1438	08/03/1977
*	WE028	698	08/03/1977
*	WE029	793	08/03/1977
*	WE030	1437	08/03/1977
*	WE031	262	08/04/1977
*	WE032	1048	08/02/1977
*	WE033	328	08/02/1977
*	WE034	907	08/02/1977
*	WE035	956	08/03/1977
*	WE036	1017	08/02/1977
*	WE037	966	08/03/1977
*	WE038	833	08/02/1977
*	WE039	510	08/03/1977
*	WE040	1168	08/03/1977
*	WE041	992	08/03/1977
*	WE042	1094	08/03/1977
*	WE043	422	08/03/1977
*	WE044	512	08/03/1977
*	WE045	293	08/03/1977
*	WE046	363	08/02/1977
*	WE047	87	08/02/1977
*	WE048	596	08/02/1977
*	WE049	624	08/03/1977
*	WE050	442	08/03/1977
*	WE051	[illegible]39	08/03/1977
*	WE052	644	08/03/1977
*	WE053	314	08/03/1977
*	WE054	376	08/02/1977

WORKING DRAFT

	WELL NO	GW STAB DEPTH CM	GW STAB DATE
*	WE055	721	08/02/1977
*	WE056	944	08/02/1977
*	WE057	705	08/02/1977
*	WE058	722	08/02/1977
*	WE059	754	08/02/1977
*	WE060	329	08/02/1977
*	WE061	1170	08/02/1977
*	WE062	189	08/03/1977
*	WE063	99	08/03/1977
*	WE064	59	08/03/1977
*	WE065	646	08/03/1977
*	WE066	340	08/02/1977
*	WE067	392	08/02/1977
*	WE068	471	08/02/1977
*	WE068	471	08/02/1977
*	WE069	1000	08/02/1977
*	WE070	948	08/03/1977
*	WE071	966	08/03/1977
*	WE072	1044	08/03/1977
*	WE073	1208	08/02/1977
*	WE074	732	08/02/1977
*	WE075	474	08/02/1977
*	WE076	437	08/02/1977
*	WE077	451	08/02/1977
*	WE078	664	08/02/1977
*	WE079	387	08/03/1977
*	WE080	358	08/03/1977
*	WE081	430	08/03/1977
*	WE082	281	08/02/1977
*	WE083	400	08/02/1977
*	WE084	71	08/02/1977
*	WE085	443	08/02/1977
*	WE086	121	08/02/1977
*	WE087	399	08/02/1977
*	WE088	623	08/02/1977
*	WE089	48	08/02/1977
*	WE090	397	08/02/1977
*	WE091	494	08/02/1977
*	WE092	361	08/02/1977
*	WE093	698	08/04/1977
*	WE094	143	08/02/1977
*	WE095	246	08/02/1977
*	WE096	155	08/03/1977
*	WE097	825	08/03/1977
*	WE098	243	08/03/1977
*	WE099	619	08/03/1977
*	WE100	496	08/03/1977
*	WE101	812	08/03/1977
*	WE102	440	08/03/1977
*	WE103	398	08/03/1977
*	WE104	328	08/03/1977
*	WE105	415	08/03/1977
*	WE1[illegible]	[illegible]	[illegible]/03/1977
*	WE107	759	08/03/1977

*	WELL NO	GW STAB DEPTH CM	GW STAB DATE
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*	WE001	1120	05/29/1977
*	WE001	1142	04/09/1977
*	WE001	1129	07/01/1977
*	WE003	1308	03/08/1977
*	WE003	1310	03/07/1977
*	WE003	1294	05/29/1977
*	WE003	1310	03/05/1977
*	WE004	1268	03/15/1977
*	WE004	1275	04/12/1977
*	WE004	1263	07/01/1977
*	WE004	1252	05/29/1977
*	WE004	1290	03/10/1977
*	WE005	30	03/11/1977
*	WE005	63	07/01/1977
*	WE005	275	05/30/1977
*	WE005	150	06/01/1977
*	WE005	85	05/29/1977
*	WE006	253	05/29/1977
*	WE006	196	03/12/1977
*	WE006	263	06/30/1977
*	WE007	786	03/14/1977
*	WE007	1458	06/06/1977
*	WE007	1500	06/28/1977
*	WE007	1573	05/29/1977
*	WE007	1259	03/26/1977
*	WE007	1573	05/29/1977
*	WE008	411	07/01/1977
*	WE008	424	03/15/1977
*	WE008	423	03/17/1977
*	WE008	421	05/29/1977
*	WE009	560	05/29/1977
*	WE009	535	07/01/1977
*	WE009	563	05/07/1977
*	WE009	578	03/18/1977
*	WE010	1215	05/29/1977
*	WE010	1227	07/01/1977
*	WE010	1218	03/17/1977
*	WE011	358	03/19/1977
*	WE011	393	06/20/1977
*	WE011	389	07/01/1977
*	WE011	361	05/29/1977
*	WE012	1233	06/26/1977
*	WE012	1243	03/21/1977
*	WE012	1233	06/28/1977
*	WE013	1248	05/29/1977
*	WE013	1272	03/22/1977
*	WE013	1260	07/01/1977
*	WE014	1165	03/24/1977
*	WE014	1252	06/30/1977
*	WE015	1165	05/29/1977
*	WE015	1175	07/01/1977
*	WE016	836	03/26/1977
*	WE016	870	05/27/1977

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	WELL NO	GW STAB DEPTH CM	GW STAB DATE
*	WE017	1150	03/28/1977
*	WE017	1134	05/29/1977
*	WE017	1164	07/06/1977
*	WE018	1310	05/29/1977
*	WE018	1322	07/02/1977
*	WE018	1320	03/30/1977
*	WE018	1311	03/29/1977
*	WE019	1045	03/30/1977
*	WE019	1330	07/01/1977
*	WE019	1322	05/29/1977
*	WE020	1271	05/29/1977
*	WE020	1284	03/31/1977
*	WE020	1288	07/02/1977
*	WE021	1189	04/01/1977
*	WE021	1191	07/02/1977
*	WE021	1176	05/29/1977
*	WE023	1376	04/05/1977
*	WE023	1363	06/28/1977
*	WE023	1366	06/26/1977
*	WE024	1479	04/05/1977
*	WE024	1454	06/28/1977
*	WE025	1413	06/28/1977
*	WE026	1298	04/07/1977
*	WE026	1300	06/28/1977
*	WE026	1298	04/07/1977
*	WE027	1406	06/28/1977
*	WE027	1116	04/08/1977
*	WE027	1406	06/25/1977
*	WE028	94	04/09/1977
*	WE028	704	06/28/1977
*	WE028	700	06/03/1977
*	WE029	781	06/28/1977
*	WE029	0	04/09/1977
*	WE030	1442	04/12/1977
*	WE030	1433	07/01/1977
*	WE030	1424	05/29/1977
*	WE031	114	04/13/1977
*	WE032	1045	07/01/1977
*	WE032	1029	05/06/1977
*	WE032	1034	04/15/1977
*	WE033	299	04/15/1977
*	WE033	322	07/01/1977
*	WE034	1123	07/02/1977
*	WE034	872	04/16/1977
*	WE035	949	04/18/1977
*	WE035	949	04/18/1977
*	WE035	948	07/02/1977
*	WE035	947	05/13/1977
*	WE036	1003	04/20/1977
*	WE036	1252	07/01/1977
*	WE036	1012	05/13/1977
*	WE036	1021	04/19/1977
*	WE036	1021	04/19/1977
*	WE037	961	04/23/1977

	WELL NO	GW STAB DEPTH CM	GW STAB DATE
*	WE037	961	04/23/1977
*	WE037	761	04/23/1977
*	WE037	961	04/23/1977
*	WE037	961	07/02/1977
*	WE038	819	05/27/1977
*	WE038	825	07/02/1977
*	WE039	1020	07/02/1977
*	WE039	1022	04/27/1977
*	WE039	505	05/30/1977
*	WE040	1169	07/02/1977
*	WE040	1170	05/30/1977
*	WE041	990	04/30/1977
*	WE041	991	07/02/1977
*	WE041	990	04/30/1977
*	WE042	1090	07/02/1977
*	WE042	713	04/30/1977
*	WE042	713	04/30/1977
*	WE042	713	04/30/1977
*	WE043	396	05/02/1977
*	WE043	396	05/02/1977
*	WE043	400	05/31/1977
*	WE043	410	06/20/1977
*	WE043	605	04/30/1977
*	WE043	414	06/28/1977
*	WE044	508	06/28/1977
*	WE044	470	05/03/1977
*	WE044	470	05/03/1977
*	WE045	300	06/28/1977
*	WE046	353	06/04/1977
*	WE046	350	05/06/1977
*	WE046	361	06/28/1977
*	WE046	352	06/06/1977
*	WE046	350	05/06/1977
*	WE047	359	06/28/1977
*	WE047	133	05/10/1977
*	WE047	133	05/10/1977
*	WE048	559	06/08/1977
*	WE048	418	05/10/1977
*	WE048	602	07/01/1977
*	WE048	418	05/10/1977
*	WE049	590	06/27/1977
*	WE049	618	05/09/1977
*	WE049	618	05/09/1977
*	WE049	595	05/29/1977
*	WE050	378	05/10/1977
*	WE050	378	05/10/1977
*	WE050	427	07/01/1977
*	WE051	561	07/01/1977
*	WE051	640	05/11/1977
*	WE051	640	05/11/1977
*	WE051	612	05/29/1977
*	WE052	627	05/12/1977
*	WE052	627	05/12/1977
*	WE053	266	06/06/1977

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	WELL NO	GW STAB DEPTH CM	GW STAB DATE
*	WE053	300	06/28/1977
*	WE053	208	05/31/1977
*	WE054	870	07/29/1977
*	WE054	810	05/24/1977
*	WE055	921	06/30/1977
*	WE055	768	05/25/1977
*	WE055	768	05/25/1977
*	WE056	771	05/26/1977
*	WE056	771	05/26/1977
*	WE056	942	06/30/1977
*	WE057	777	06/30/1977
*	WE058	721	06/30/1977
*	WE058	413	05/28/1977
*	WE058	413	05/28/1977
*	WE059	733	05/28/1977
*	WE059	733	05/28/1977
*	WE059	744	06/30/1977
*	WE060	268	05/30/1977
*	WE060	268	05/30/1977
*	WE060	307	06/30/1977
*	WE060	288	06/08/1977
*	WE061	1167	06/13/1977
*	WE061	1168	06/27/1977
*	WE061	1179	05/31/1977
*	WE061	1168	06/08/1977
*	WE061	1179	05/31/1977
*	WE062	175	06/28/1977
*	WE062	151	06/01/1977
*	WE062	151	06/01/1977
*	WE063	95	06/02/1977
*	WE063	105	06/28/1977
*	WE063	95	06/02/1977
*	WE064	58	06/03/1977
*	WE064	71	06/28/1977
*	WE064	58	06/03/1977
*	WE065	647	06/30/1977
*	WE066	324	06/28/1977
*	WE066	329	06/06/1977
*	WE066	329	06/06/1977
*	WE067	382	06/28/1977
*	WE068	505	06/08/1977
*	WE068	505	06/08/1977
*	WE068	469	06/24/1977
*	WE068	469	06/28/1977
*	WE069	996	06/13/1977
*	WE069	996	06/13/1977
*	WE069	998	06/30/1977
*	WE070	944	06/11/1977
*	WE070	949	07/01/1977
*	WE070	944	06/11/1977
*	WE071	881	06/11/1977
*	WE071	881	06/11/1977
*	WE072	1041	07/01/1977
*	WE072	1039	06/13/1977

WORKING DRAFT

	WELL NO	GW STAB DEPTH CM	GW STAB DATE
*	WE072	1039	06/13/1977
*	WE073	1213	06/14/1977
*	WE073	1208	06/30/1977
*	WE073	1213	06/14/1977
*	WE074	1239	06/15/1977
*	WE074	728	06/30/1977
*	WE074	1239	06/15/1977
*	WE075	470	06/16/1977
*	WE075	470	06/16/1977
*	WE075	473	06/18/1977
*	WE075	472	06/30/1977
*	WE076	433	06/18/1977
*	WE076	245	06/17/1977
*	WE076	245	06/17/1977
*	WE076	434	06/30/1977
*	WE076	433	06/18/1977
*	WE077	472	06/18/1977
*	WE077	472	06/18/1977
*	WE077	458	06/30/1977
*	WE078	724	06/20/1977
*	WE078	561	06/27/1977
*	WE078	652	07/02/1977
*	WE078	724	06/20/1977
*	WE078	948	07/29/1977
*	WE079	378	07/01/1977
*	WE079	377	06/21/1977
*	WE079	377	06/21/1977
*	WE080	390	06/22/1977
*	WE080	368	06/28/1977
*	WE080	390	06/22/1977
*	WE081	478	06/23/1977
*	WE081	478	06/23/1977
*	WE082	280	07/04/1977
*	WE082	280	07/04/1977
*	WE083	400	07/06/1977
*	WE083	400	07/05/1977
*	WE083	400	07/05/1977
*	WE084	81	07/06/1977
*	WE084	81	07/06/1977
*	WE085	438	07/07/1977
*	WE085	438	07/07/1977
*	WE086	147	07/08/1977
*	WE086	147	07/08/1977
*	WE087	381	07/09/1977
*	WE087	381	07/09/1977
*	WE088	622	07/09/1977
*	WE088	622	07/09/1977
*	WE089	41	07/11/1977
*	WE089	41	07/11/1977
*	WE090	380	07/11/1977
*	WE091	494	07/13/1977
*	WE092	363	07/13/1977
*	WE093	688	07/15/1977
*	WE096	155	07/16/1977

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	WELL NO	GW STAB DEPTH CM	GW STAB DATE
*	WE097	821	07/18/1977
*	WE098	244	07/20/1977
*	WE099	502	07/20/1977
*	WE099	620	07/21/1977
*	WE100	470	07/22/1977
*	WE100	491	07/23/1977
*	WE100	497	07/25/1977
*	WE101	570	07/23/1977
*	WE101	572	07/25/1977
*	WE102	410	07/23/1977
*	WE102	412	07/23/1977
*	WE102	510	07/23/1977
*	WE102	424	07/25/1977
*	WE103	387	07/25/1977
*	WE103	530	07/25/1977
*	WE103	386	07/25/1977
*	WE103	387	07/25/1977
*	WE104	320	07/25/1977
*	WE104	422	07/25/1977
*	WE104	316	07/26/1977
*	WE105	414	07/29/1977
*	WE105	414	07/27/1977
*	WE106	667	07/28/1977
*	WE106	668	07/29/1977
*	WE107	758	07/29/1977

APPENDIX B: LABORATORY SOIL TEST PROCEDURES

Physical Test

Standard soil test procedures as specified by Engineer Manual 1110-2-1906, "Laboratory Soil Testing," were followed during testing.

Unified Soil Classification System

Classification of soils according to the USCS depends upon grain-size distribtution and the Atterberg limits. Grain-size distribution is determined with sieves and a hydrometer, and the liquidity and plasticity (Atterberg limits) are determined with standard devices. The liquid and plastic limits are the water contents at the boundaries between the semiliquid and plastic state and the plastic and semisolid state, respectively. Figure B1 shows the USCS by which the PBA soil samples were described. Figures B2-B7 present the laboratory data sheets for the classification of two samples; one a coarse-grained material (SP-SM) and the other a fine-grained material (CL).

Water Content and Density

Water content and soil density are important engineering relationships and are useful correlations among samples for which a full suite of physical test data are not available. Water content is the amount of free water in a soil and is determined to the following formula:

$$W = \frac{W_w}{W_s}$$

where W = water content

W_w = weight of water

W_s = dry weight of soil

Density or dry unit weight is determined according to the following formula:

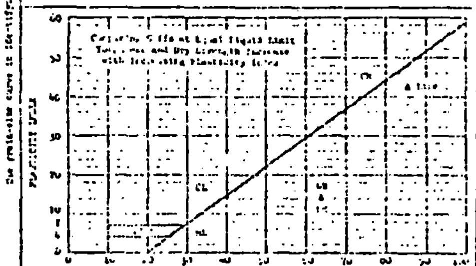
$$D = \frac{W_s}{V}$$

UNIFIED SOIL CLASSIFICATION
(Including Identification and Description)

Major Divisions (1)	(2)		Group Symbols (3)	Typical Names (4)	Field Identification Procedures (Excluding particles larger than 3 in. and basing fractions on estimated weights) (5)	Information Required for Describing Soils (6)	Laboratory Classification Criteria (7)
Coarse-grained Soils. More than half of material is larger than No. 200 sieve size. (The No. 200 sieve size is about the smallest particle visible to the naked eye.)	Gravels. More than half of coarse fraction is larger than No. 4 sieve size. (For visual classification, the 1/4-in. size may be used as equivalent to the No. 4 sieve size)	Clean Gravels (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.	Wide range in grain sizes and substantial amounts of all intermediate particle sizes.	For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions, and drainage characteristics.	Use grain-size curve in identifying the fractions as given under field identification. Determine percentages of gravel and sand from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size) coarse-grained soils are classified as follows: Less than 5% GW, GP, SW, SP. More than 12% GM, GC, SM, SC. 5% to 12% Borderline cases requiring use of dual symbols. — $C_u = \frac{D_{60}}{D_{10}}$ Greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			GP	Poorly graded gravels or gravel-sand mixtures, little or no fines.	Predominantly one size or a range of sizes with some intermediate sizes missing.		Not meeting all gradation requirements for GW
		Gravels with Fines (Appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixtures.	Nonplastic fines or fines with low plasticity (for identification procedures see ML below).	Give typical name; indicate approximate percentages of sand and gravel, max. size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbol in parentheses.	Atterberg limits below "A" line or PI less than 4. Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols.
			GC	Clayey gravels, gravel-sand-clay mixtures.	Plastic fines (for identification procedures see CL below).		Atterberg limits above "A" line with PI greater than 7
	Sands. More than half of coarse fraction is smaller than No. 4 sieve size.	Clean Sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines.	Wide range in grain size and substantial amounts of all intermediate particle sizes.		$C_u = \frac{D_{60}}{D_{10}}$ Greater than 6; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			SP	Poorly graded sands or gravelly sands, little or no fines.	Predominantly one size or a range of sizes with some intermediate sizes missing.	Example: Silty sand, gravelly; about 20% hard, angular gravel particles 1/2-in. maximum size, rounded and subangular sand grains, coarse to fine, about 15% nonplastic fines with low dry strength; well compacted and moist in place; alluvial sand; (SM).	Not meeting all gradation requirements for SW
		Sands with Fines (Appreciable amount of fines)	SM	Silty sands, sand-silt mixtures.	Nonplastic fines or fines with low plasticity (for identification procedures see ML below).		Atterberg limits below "A" line or PI less than 5. Above "A" line with PI between 5 and 7 are borderline cases requiring use of dual symbols.
			SC	Clayey sands, sand-clay mixtures.	Plastic fines (for identification procedures see CL below).		Atterberg limits above "A" line with PI greater than 7

Identification Procedures on Fraction Smaller than No. 40 Sieve Size

Major Divisions (1)	(2)	Group Symbols (3)	Typical Names (4)	Dry Strength (Crushing characteristics)	Dilatancy (Reaction to shaking)	Toughness (Consistency near PL)	Information Required for Describing Soils (6)
Fine-grained Soils. More than half of material is smaller than No. 200 sieve size. (The No. 200 sieve size is about the smallest particle visible to the naked eye.)	Silts and Clays. Liquid limit is less than 50	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.	None to slight	Quick to slow	None	For undisturbed soils add information on structure, stratification, consistency in undisturbed and remolded states, moisture and drainage conditions.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.	Medium to high	None to very slow	Medium	
		OL	Organic silts and organic silty clays of low plasticity.	Slight to medium	Slow	Slight	Give typical name; indicate degree and character of plasticity; amount and maximum size of coarse grains; color in wet condition; odor, if any; local or geologic name and other pertinent descriptive information; and symbol in parentheses.
	Silts and Clays. Liquid limit is greater than 50	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.	Slight to medium	Slow to none	Slight to medium	
		CH	Inorganic clays of high plasticity, fat clays.	High to very high	None	High	
		OH	Organic clays of medium to high plasticity, organic silts.	Medium to high	None to very slow	Slight to medium	Example: Clayey silt, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (ML).
Highly Organic Soils		Pt	Peat and other highly organic soils.	Readily identified by color, odor, spongy feel and frequently by fibrous texture.			



LIQUID LIMIT

PLASTICITY CHART

For laboratory classification of fine-grained soils

(1) Boundary classifications. Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, well-graded gravel-sand mixture with clay binder. (2) All sieve sizes on this chart are U. S. standard.

FIELD IDENTIFICATION PROCEDURES FOR FINE-GRAINED SOILS OR FRACTIONS

These procedures are to be performed on the minus No. 40 sieve size particles, approximately 1/64 in. For field classification purposes, screening is not intended, simply remove by hand the coarse particles that interfere with the tests.

Dilatancy (reaction to shaking)

After removing particles larger than No. 40 sieve size, prepare a pat of moist soil with a volume of about one-half cubic inch. Add enough water if necessary to make the soil soft but not sticky.

Place the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the pat stiffens, and finally it cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil.

Very fine clean sands give the quickest and most distinct reaction whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour, show a moderately quick reaction.

Dry Strength (crushing characteristics)

After removing particles larger than No. 40 sieve size, mold a pat of soil to the consistency of putty, adding water if necessary. Allow the pat to dry completely by oven, sun or air-drying, and then test its strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.

High dry strength is characteristic for clays of the CH group. A typical inorganic silt possesses only very slight dry strength. Silty fine sands and silts have about the same slight dry strength, but can be distinguished by the feel when powdering the dried specimen. Fine sand feels gritty whereas a typical silt has the smooth feel of flour.

Toughness (consistency near plastic limit)

After particles larger than the No. 40 sieve size are removed, a specimen of soil about one-half inch cube in size, is molded to the consistency of putty. If too dry, water must be added and if sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about one-eighth inch in diameter. The thread is then folded and rerolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached.

After the thread crumbles, the pieces should be lumped together and a slight kneading action continued until the lump crumbles.

The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at the plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as kaolin-type clays and organic clays which occur below the A-line.

Highly organic clays have a very weak and spongy feel at the plastic limit.

Adopted by Corps of Engineers and Bureau of Reclamation, January 1952

Figure B1. Unified Soil Classification System

SIEVE ANALYSIS

Date 4 Jan 78

Project Pine Wh. Arsenal

Boring No. 01 Sample No. 7 (1449-1500 cm)

Total wt in grams of sample W_s = | Wt in grams of material > No. 4 sieve =

Sieve Openings: Inches	Sieve Openings: Millimeters	U.S. Standard Sieve Size or Number	Weight Retained in grams	Percent Retained: Partial	Percent Retained: Total	Percent Finer by weight
3.00		3-in				
2.00		2-in				
1.50		1-1/2-in				
1.00	25.4	1-in				
0.750	19.1	3/4-in				
0.500	12.7	1/2-in				
0.375	9.52	3/8-in				
0.250	6.35	No 3				
0.187	4.76	No 4				
		Pan				
0.132	3.36	No 6	0.3		0.2	99.8
0.094	2.38	No 8	—	—	—	—
0.079	2.00	No 10	0.7		0.5	99.5
0.047	1.19	No 16	1.0		0.7	99.3
0.033	0.84	No 20	1.2		0.9	99.1
0.023	0.59	No 30	1.4		1.0	99.0
0.0165	0.42	No 40	1.6		1.2	98.8
0.0117	0.297	No 50	2.3		1.7	98.3
0.0083	0.210	No 70	13.3		9.6	90.4
0.0059	0.149	No 100	72.8		52.8	47.2
0.0041	0.105	No 140	115.4		83.7	16.3
0.0029	0.074	No 200	129.8		94.1	5.9
		Pan				
Total weight in grams 137.9						

Partial percent retained = $\frac{\text{wt in grams retained on sieve}}{\text{wt in grams of sample used for a given series of sieves}} \times 100$

Total percent retained = $\frac{\text{wt in grams retained on a sieve}}{\text{total wt in grams of oven-dry sample}} \times 100$

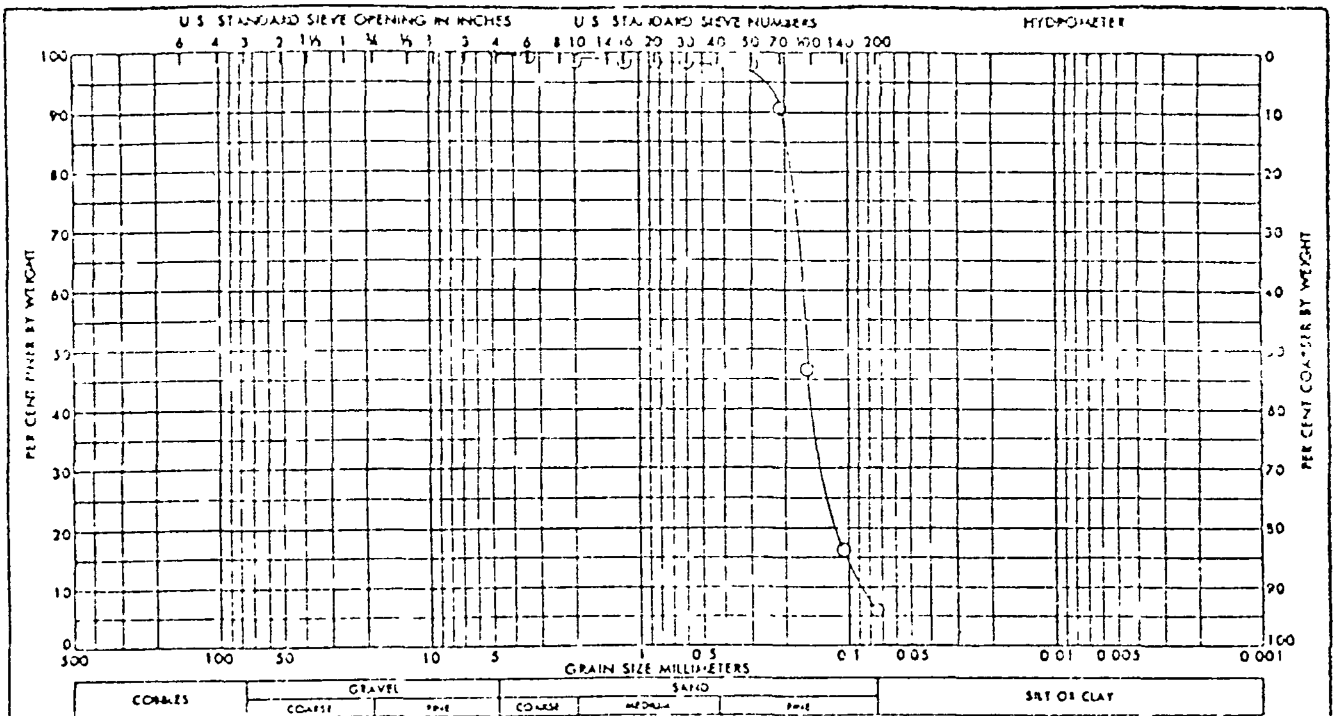
For an individual sieve, the percent finer by weight = percent finer than next larger sieve - percent retained on individual sieve

Remarks Fines Non Plastic (SP-SM) Tan

Technician RE Computed by RE Checked by KR

ENG FORM 1 JUN 65 3841 PLATE V-1

Figure B2. Sieve analysis for boring No. 1, sample No. 7



SAMPLE NO.	ELEV OR DEPTH	CLASSIFICATION	NAT W%	LL	PL	PI
7	1449-1500	SAND(SP-SM) TAN		NP		
		Gs = 2.65(est)				
		K_{20} = 1.9 x 10^{-3} CM/SEC				
		= 99.6 PCF				

GRADATION CURVES

PROJECT HYDROGEOLOGICAL SURVEY OF PINE BLUFF ARSENAL

AREA

BORING NO. 01A

DATE 22 FEB 73

ENG FORM 1 MAY 63 2087 REPLACES WES FORM NO. 1241, SEP 1962, WHICH IS OBSOLETE

Figure B3. Grain size distribution for boring No. 1, sample No. 7

Date 8 Dec 77

Project Pine Bluff Arsenal Hydrogeological Survey

Boring No. 01 Sample No. 5 (874-918 cm)

Total wt in grams of sample, W_s =					wt in grams of material > No. 4 sieve =		
Sieve Openings		U.S. Standard Sieve Size or Number	Weight Retained in grams	Percent Retained		Percent Finer by weight
Inches	Millimeters			Partial	Total	
3.00		3-in				
2.00		2-in				
1.50		1-1/2-in				
1.00	25.4	1-in				
0.750	19.1	3/4-in				
0.500	12.7	1/2-in				
0.375	9.52	3/8-in				
0.250	6.35	No. 3				
0.187	4.76	No. 4				
		Pan				
0.132	3.36	No. 6				
0.094	2.38	No. 8				
0.079	2.00	No. 10				
0.047	1.19	No. 16				
0.033	0.84	No. 20				
0.023	0.59	No. 30				
0.0165	0.42	No. 40				100
0.0117	0.297	No. 50	0.1			99.8
0.0083	0.210	No. 70	0.2			99.7
0.0059	0.149	No. 100	0.3			99.5
0.0041	0.105	No. 140	0.4			99.3
0.0029	0.074	No. 200	1.0			98.3
		Pan				
Total weight in grams						

Partial percent retained = $\frac{\text{wt in grams retained on a sieve}}{\text{wt in grams of sample used for a given series of sieves}} \times 100$

Total percent retained = $\frac{\text{wt in grams retained on a sieve}}{\text{total wt in grams of original sample}} \times 100$

For an individual sieve, the percent finer by weight = percent finer than next larger sieve - percent retained on individual sieve

Remarks

Technician RE Computed by RE Checked by KR

ENG FORM 1 JUN 65 3341 PLATE V-1

Figure B4. Sieve Analysis for boring No. 1, sample No. 5

Pine Bluff Arsenal Hydrogeological Survey — 20 Nov 77

01

5 (874 918 ...) — CL

H-22

Sod Tet — 60 cc

Dispersing agent correction, C_d = — , ... correction, C_m =

[illegible]	Elapsed time	Temp °C	Hydrometer reading (R')	Corrected reading (R)	Particle diameter (D), mm	Temp correction (m)	R - C_d + m	Percent finer: Partial	Percent finer: Total
	1	30	30 0	30 5	0 041		30 1		80 0
	2	↓	25 8	26 3	0 031		25 9		68 9
	4		20 2	20 7	0 023		20 3		54 0
	15		14 9	15 4	0 0129		15 0		40 0
	30	↓	13 4	13 9	0 0092		13 5		35 9
	60	40	12 0	12 5	0 0066		12 3		32 7
	120	↓	10 8	11 3	0 0048		11 1		29 5
	240	50	10 0	10 5	0 0034		10 5		27 9
	1440	30	9 4	9 9	0 0014		9 5		25 3

Weight in grams		
Dish plus dry soil		
Dish		
Dry soil 60 0	W_o	

Specific gravity of solids, G_s = 2.62 est

Corrected hydrometer reading (R) = hydrometer reading (R') + C_m

The particle diameter (D) is calculated from Stoke's equation using corrected hydrometer reading. Use nomographic chart for solution of Stoke's equation.

Hydrometer graduated in specific gravity

$$\text{Partial percent finer} = \frac{G_s}{G_s - 1} \times \frac{100}{W_o} (R - C_d + m)$$

Hydrometer graduated in grams per liter

$$\text{Partial percent finer} = \frac{100}{W_o} (R - C_d + m)$$

$$\text{Total percent finer} = \text{partial percent finer} \times \frac{W_s - W_1}{W_s}$$

W_s = total oven-dry wt of sample used for combined analysis

W_o = oven-dry wt in grams of soil used for hydrometer analysis

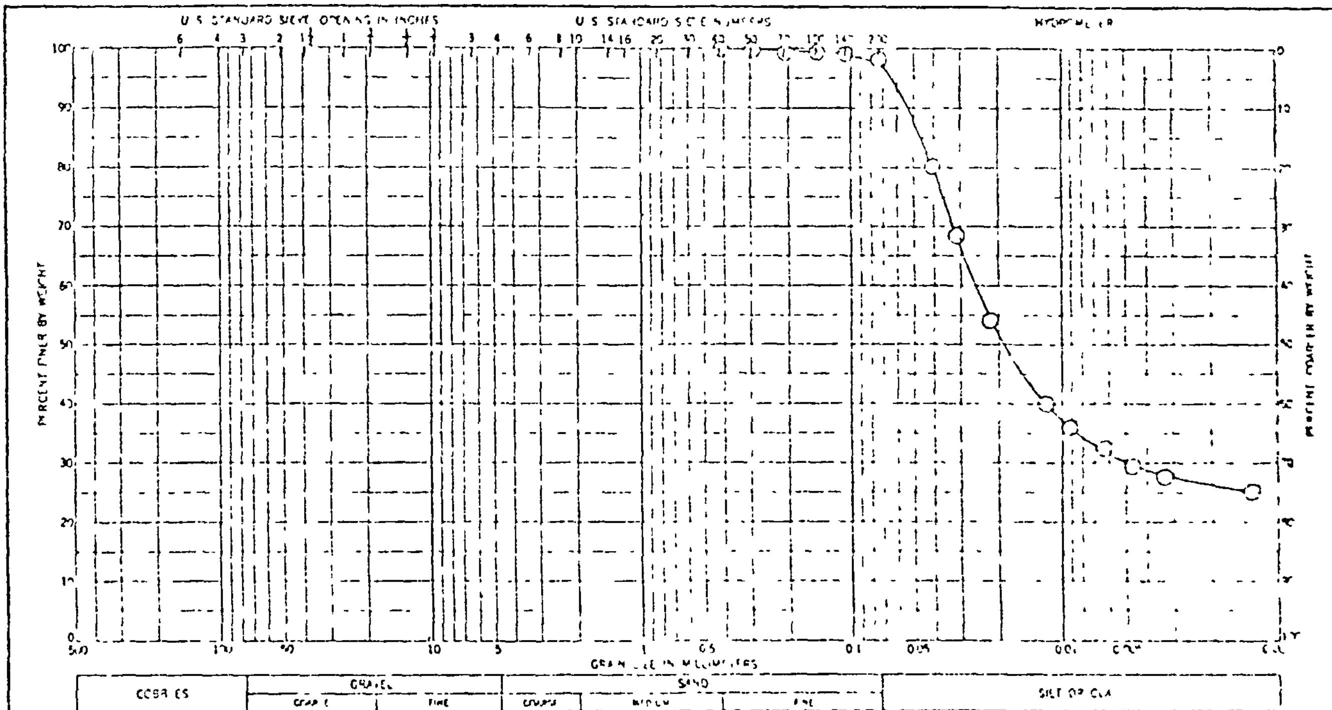
W_1 = oven-dry wt of sample retained on No. 200 sieve

Remarks

Technician RC Computed by RC Checked by KR

ENG FORM 3842 1 JUN 65 — D43-99

Figure B5. Hydrometer analysis for boring No. 1, sample No. 5



Sample No.	Elev or Depth	Classification	Nat w%	LL	PL	PI
5	874-918	LEAN CLAY (CL) RED Gs= 2.68(est)	20.7	37	17	15
		γD = 104.4 pcf				

Project HYDROGEOLOGICAL SURVEY OF PINE BLUFF ARSENAL

Area

Boring No. 01A

Date 12 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure B6. Grain size distribution for boring No. 1, sample No. 5

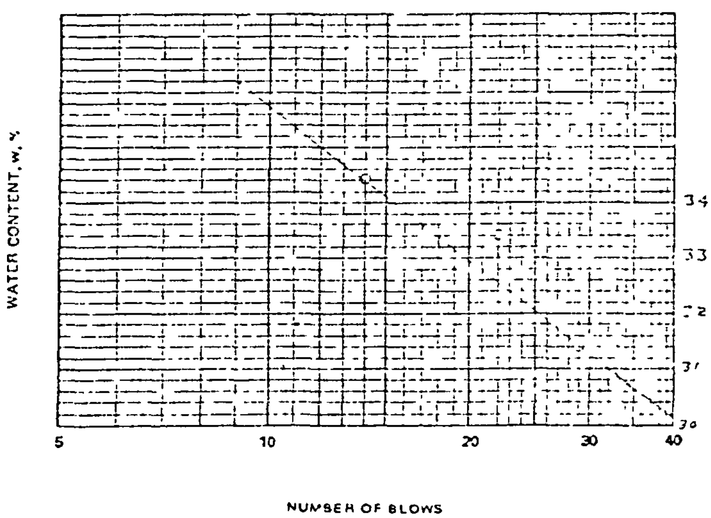
LIQUID AND PLASTIC LIMIT TESTS

PROJECT Pine [illegible] Personal [illegible] Survey DATE [illegible]

BORING NO 01 SAMPLE NO [illegible]

LIQUID LIMIT

RUN NO		1	2	3	4	5	6
TARE NO		11	13	15	17		
WEIGHT IN GRAMS	TARE PLUS WET SOIL	60.98	59.43	59.4[illegible]	62.36		
	TARE PLUS DRY SOIL	54.69	53.69	53.87	56.36		
	WATER W_w	6.29	5.74	5.5[illegible]	6.00		
	TARE	16.39	16.19	16.06	16.14		
	DRY SOIL W_s	18.30	[illegible]	[illegible]	[illegible]		
WATER CONTENT % w		34.[illegible]	33.[illegible]	31.4	30.7		
NUMBER OF BLOWS		12	22	29	35		



LL 32.0

PL 17.0

PI 15.0

Symbol from plasticity chart CL

PLASTIC LIMIT

RUN NO		1	2	3	4	5	NATURAL WATER CONTENT
TARE NO		57	56				
WEIGHT IN GRAMS	TARE PLUS WET SOIL	46.34	46.0[illegible]				
	TARE PLUS DRY SOIL	44.94	44.75				
	WATER W_w	1.40	1.33				
	TARE	36.72	37.12				
	DRY SOIL W_s	8.22	7.6[illegible]				
WATER CONTENT % w		17.0	17.4				
PLASTIC LIMIT		17.2					

REMARKS Sil Clay (CL) Lt Red

TECHNICIAN RD COMPUTED BY RD CHECKED BY KR

ENC FORM 1 JUN 65 3838

Figure B7. Liquid and plastic limits for boring No. 1, sample No. 5

where D = density

W_s = dry weight of soil

V = volume of soil

Permeability

Permeability is a measure of a soil's ability to transmit a fluid; in the current study the fluid is water. The flow of water through a soil is governed by Darcy's law:

$$q = KiA$$

where q = rate of discharge through a soil of cross-sectional area A

K = coefficient of permeability

i = hydraulic gradient (the loss of hydraulic head per unit distance of flow)

A = sample area perpendicular to flow

For coarse-grained materials, permeability tests are usually conducted in a constant head apparatus. In this equipment, an overflowing reservoir maintains a constant head on a soil sample of specified dimensions and the amount of water passing through the soil in a specified time is collected and measured. The permeability is then calculated according to the formula:

$$K_{20} = \frac{QLR_t}{hAt}$$

where K_{20} = coefficient of permeability, cm/sec at 20°

Q = quantity of flow, cc

L = length of specimen over which head loss is measured, cm. If piezometer taps are used, L is equal to the distance between piezometer taps.

R_t = temperature correction factor for viscosity of water

h = head loss across sample or between piezometer taps, cm

A = cross-sectional area of specimen, sq cm

t = elapsed time, sec

Figure B8 is a schematic representation of the testing apparatus and Figure B9 is the data set from boring No. 8, sample No. 5.

Permeability tests for fine-grained soils are usually performed on confined specimens which permit an increase of pressure, thus decreasing gas volume and increasing saturation. The head is allowed to fall during the test, and permeability is calculated according to the formula:

$$K_{20} = \frac{2.303\ aLR_t \ \log \frac{ho}{hf}}{At}$$

where K_{20} = coefficient of permeability, cm/sec at 20°C

a = inside area of standpipe, sq cm

A = cross-sectional area of specimen, sq cm

L = length of specimen, cm

t = elapsed time $(t_f - t_o)$, sec

h_o = height of water in standpipe above discharge level at time t_o, cm

h_f = height of water in standpipe above discharge level at time T_f, cm

R_t = temperature correction factor for viscosity of water

Figure B10 is a schematic representation of the testing apparatus and Figure B11 is the data set from boring No. 12, sample No. 2.

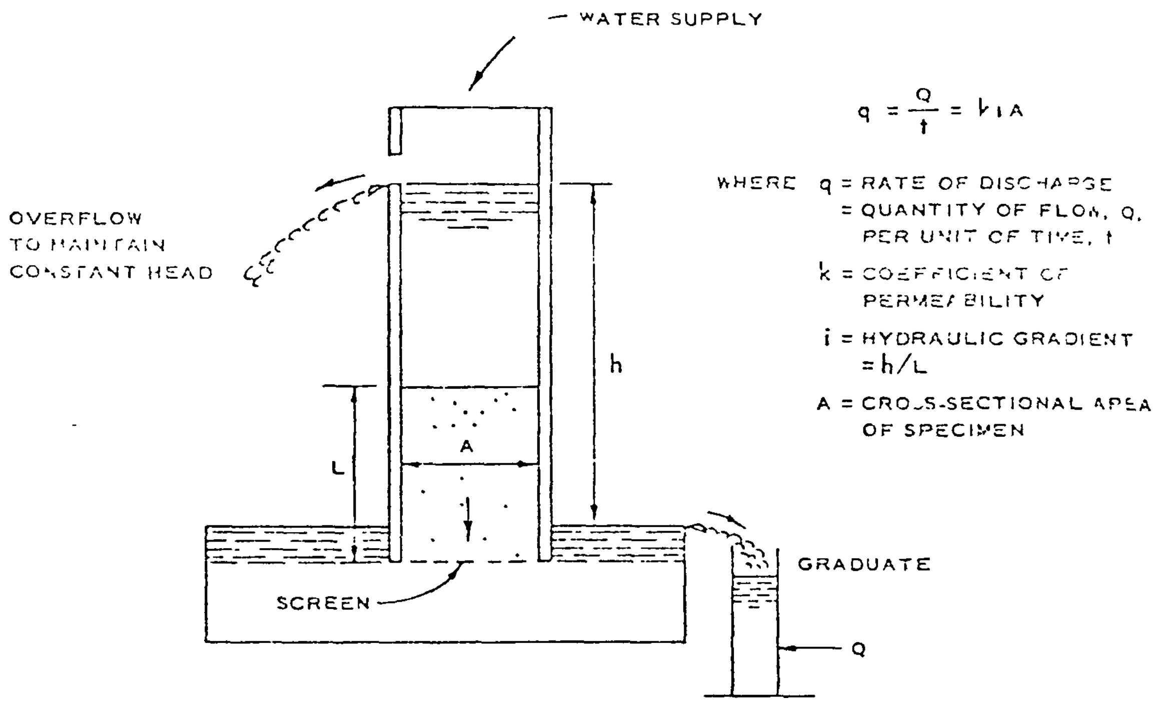


Figure B8. Schematic representation of constant head testing apparatus [illegible] 27 [illegible]

[illegible] Blue Ridge General Hydrogeological Survey

Boring No. 8

[illegible] No. 5

[illegible] dry soil		411.55	Area of specimen, cm²	[illegible]	7.15?
Tare		51.70	Volume of specimen, cc	[illegible]	40.583
Dry soil	W_s	359.85	Initial height of specimen, cm	L	5.651
Specific gravity	G	2.65 est	Vol. of voids, cc	V	.2?324
Volume of solids, cc	V_s	135.?2	[illegible]	[illegible]	.?6??

Distance between piezometer taps, cm L_1

Test No		1		2		3	
Height of specimen, cm	L	5.651		5.651		5.651	
Void ratio = $(AL - V_s) \div V_s$	e						
		1a	1b	2a	2b	3a	3b
Reading of piez 1, cm	h_1	54		54		54?	
Reading of piez 2, cm	h_2	40		40		40?	
Head loss, cm = $h_1 - h_2$	h	14		14		14?	
Quantity of flow, cc	Q	100		100		100	
Elapsed time, sec	t	42		46		47	
Water temperature, °C	T	24.4		24.4		24.4	
Viscosity correction factor(1)	R_T	0.901		0.901		0.901	
Coefficient of permeability,(2) cm/sec	k_{20}						
	A-E	2.13×10^{-2}		1.95×10^{-2}		1.91×10^{-2}	

(1) Correction factor for viscosity of water at 20 C obtained from table VII-1.

(2) $k_{20} = \frac{Q \times L \times R_T}{h \times A \times t}$.

where L = height of specimen or distance between piezometer taps if used.

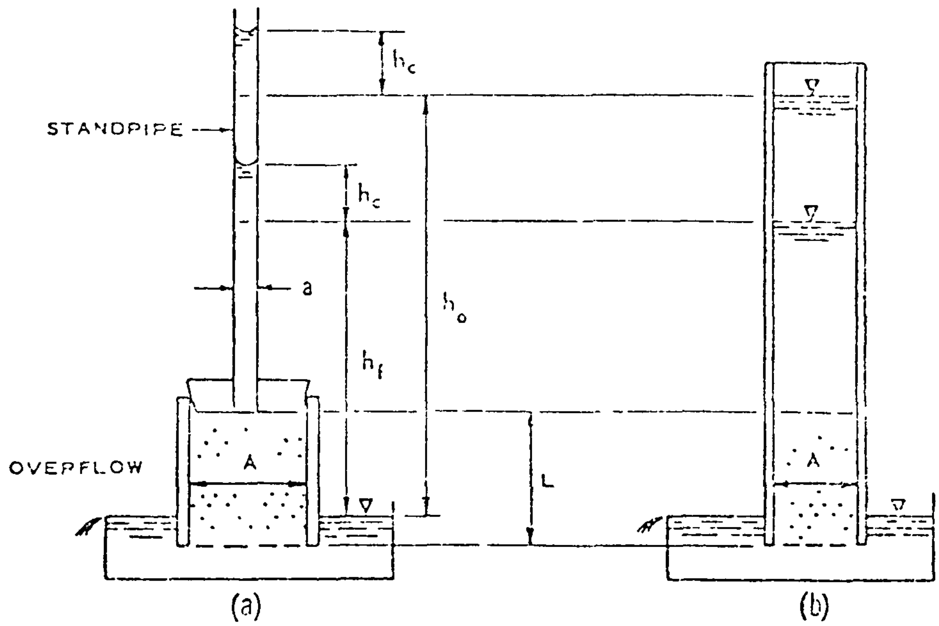
Avg $K_{20} = 2.0 \times 10^{-2}$ cm/sec

Remarks

Technician RE   Computed by RE   Checked by KR

ENG FORM 3844 1 JUN 64   [illegible]

Figure B9 Constant head permeability data for boring No. 8, sample No. 5



USING SETUP SHOWN IN (a), THE COEFFICIENT OF PERMEABILITY IS DETERMINED AS FOLLOWS

$$k = \frac{La}{At} \ln \frac{h_o}{h_f} = 2.303 \frac{La}{At} \log_{10} \frac{h_o}{h_f}$$

USING SETUP SHOWN IN (b), THE COEFFICIENT OF PERMEABILITY IS DETERMINED AS FOLLOWS

$$k = \frac{L}{t} \ln \frac{h_o}{h_f} = 2.303 \frac{L}{t} \log_{10} \frac{h_o}{h_f}$$

WHERE, h_c = HEIGHT OF CAPILLARY RISE
a = INSIDE AREA OF STANDPIPE
A = CROSS-SECTIONAL AREA OF SPECIMEN
L = LENGTH OF SPECIMEN
h_o = HEIGHT OF WATER IN STANDPIPE ABOVE DISCHARGE LEVEL MINUS h_c AT TIME, t_o
h_f = HEIGHT OF WATER IN STANDPIPE ABOVE DISCHARGE LEVEL MINUS h_c AT TIME, t_f
t = ELAPSED TIME, $t_f - t_o$

Figure B10. Schematic representation of falling head testing apparatus

PRE-SCORE

REFERENCE 8

MITRE

26 May 1989
W52-[illegible]

Ms Lucy Sibold
U S Environmental Protection Agency
401 M Street, S W
Room 2636, Mail Code WH-548A
Washington, D C. 20460

Dear Ms Sibold

Enclosed is a copy of the draft revised HRS net precipitation values for 3,345 weather stations where data were available. The data are presented by state code, station name, latitude longitude, and net precipitation in inches A list of state codes is also enclosed

The net precipitation values are provided to assist the Phase II - Field Testing efforts. It is suggested that the value from the nearest weather station in a similar geographic setting be used as the net precipitation value for a site

If there are any questions regarding this material, please contact Dave Egan at (703) 883-7866

Sincerely,

Andrew M. Platt
Group Leader
Hazardous Waste Systems

AMP:DEE/hme

Enclosures

cc: Scott Parrish

The MITRE Corporation
Civil Systems Division
7525 Colshire Drive, McLean, Virginia 22102-3481
Telephone (703) 883-6000 Telex 248923

OBS	STATE	NAME	LATNUM	LONNUM	NETPREC
111	02	KINGMAN NO 2	35.12	114.01	1.6903
112	02	WILLIAMS	35.15	112.11	7.3605
113	02	FORT VALLEY	35.16	111.44	9.5211
114	02	LEUPP	35.17	110.58	0.9078
115	02	SELIGMAN	35.19	112 53	2.1134
116	02	TRUXTON CANYON	35.23	113.40	1.7778
117	02	WUPATKI NAT MON	35.31	111.22	0.8235
118	02	WINDOW ROCK	35.41	109.03	3.0179
119	02	GANADO	35.43	109.34	2.9441
120	02	BETATAKIN	36.41	110.32	3.8386
121	02	LEES FERRY	36.52	111.36	0.6941
122	03	CROSSETT 7 S	33.02	91.56	25.1673
123	03	EL DORADO FAA AIRPORT	33.13	92.48	21.8131
124	03	MAGNOLIA 3 N	33.19	93.14	22.0124
125	03	TEXARKANA FAA AIRPORT	33.27	94.00	17.4776
126	03	MONTICELLO 3 SW	33.36	91.49	24.4908
127	03	WARREN	33.36	92.04	24.3038
128	03	CAMDEN 1	33.36	92.49	22.0654
129	03	HOPE 3 NE	33.43	93.33	22.5447
130	03	OKAY	33.46	93.55	20.2713
131	03	PRESCOTT	33.48	93.23	23.7031
132	03	DUMAS	33.53	91.29	23.0191
133	03	NASHVILLE EXP STATION //	34.00	93.56	24.2495
134	03	DE QUEEN	34.02	94.21	22.5659
135	03	ARKADELPHIA 2 N	34.09	93.03	23.7258
136	03	PINE BLUFF	34.13	92.01	23.3561
137	03	SAINT CHARLES	34.23	91.08	24.2312
138	03	MALVERN	34.23	92.49	25.5101
139	03	STUTTGART 9 ESE	34.28	91.25	22.6920
140	03	STUTTGART	34.29	91.32	23.4874
141	03	HOT SPRINGS 1 NNE	34.31	93.03	25.2521
142	03	MOUNT IDA 3 SE	34.32	93.36	26.2710
143	03	BENTON	34.33	92.37	24.6104
144	03	HELENA 5 NW	34.34	90.40	24.6298
145	03	MENA	34.35	94.15	24.1295
146	03	KEO	34.36	92.00	21.8734
147	03	MARIANNA 2 S	34.44	90.46	24.2389
148	03	LITTLE ROCK WSO //R	34.44	92.14	22.3317
149	03	ALUM FORK	34.48	92.52	23.7426
150	03	NO. LITTLE ROCK WSFO	34.50	92.16	21.0392
151	03	BRINKLEY	34.53	91.12	23.6909
152	03	WALDRON	34.54	94.06	18.0537
153	03	NIMROD DAM	34.57	93.10	20.4557
154	03	DES ARC	34.58	91.30	23.9062
155	03	CONWAY	35.05	92.28	22.2733
156	03	MORRILTON	35.08	92.44	19.6811
157	03	DARDANELLE	35.13	93.09	19.9652
158	03	WYNNE	35.14	90.47	23.0134
159	03	SEARCY	35.15	91.45	23.6858
160	03	SUBIACO	35.18	93.39	17.6134
161	03	RUSSELLVILLE 4 N	35.20	93.09	20.7417
162	03	FORT SMITH WSO //R	35.20	94.22	15.2076
163	03	OZARK	35.29	93.50	16.9527
164	03	NEWPORT	35.36	91.17	21.5564
165	03	BATESVILLE L AND D 1	35.45	91.38	20.6040

PRE-SCORE

REFERENCE 9

Hole No.

DRILLING LOG	DIVISION SOUTHWEST	INSTALLATION PINE BLUFF ARSENAL	SHEET OF SHEETS

1 PROJECT: WASTE LANDFILL AREA	10 SIZE AND TYPE OF BIT [illegible]
2 LOCATION (Coordinates or Station) [illegible]	11 DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL 316.66
3 DRILLING AGENCY: USCE	12 MANUFACTURER'S DESIGNATION OF DRILL: CME
4 HOLE NO (As shown on drawing title and file number): 188	13 TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED: 2; UNDISTURBED:
5 NAME OF DRILLER: JAMES WYATT	14 TOTAL NUMBER CORE BOXES: NONE
6 DIRECTION OF HOLE: ☑ VERTICAL ☐ INCLINED ____ DEG FROM VERT	15 ELEVATION GROUND WATER
	16 DATE HOLE — STARTED: 8-31-83; COMPLETED: 9-1-83
7 THICKNESS OF OVERBURDEN: 35.0+	17 ELEVATION TOP OF HOLE: + 2.8
8 DEPTH DRILLED INTO ROCK: 0.0	18 TOTAL CORE RECOVERY FOR BORING: NONE %
9 TOTAL DEPTH OF HOLE: 35.0	19 SIGNATURE OF INSPECTOR: Bill [illegible]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0–18.0		0.0-18.0 CLAY (CL) sandy, soft to med stiff, damp, yellow brown			8-31-83 CME ran 6-in sp. auger to 35.0' water at 21.5. 10-in fishtail to 35.0' end of shift. Set 4-in [illegible] with screen see drawing
	18.0–21.0		18.0-21.0 CLAY. Med. stiff damp red brown, sl sandy			
	21.0–28.0		21.0-28.0 SAND (SP) fine, tan, dense, saturated, wet at 21.5'		28.0	
	28.0–31.0		28.0-31.0 SAND (SC fine gr, clayey, tan, saturated.		J-1 30.0	SC-SM
	31.0–33.0		31.0-33.0' CLAY (CL) med. stiff, damp sandy, dark brown		J-2 33.0	CL-ML, sdy

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: LAND WASTEFILL AREA | HOLE NO: 188

Hole No 188

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 2 SHEETS

1 PROJECT	10 SIZE AND TYPE OF BIT
2 LOCATION (Coordinates or Station)	11 DATUM FOR ELEVATION SHOWN (TBM or MSL)
3 DRILLING AGENCY	12 MANUFACTURER'S DESIGNATION OF DRILL
4 HOLE NO (As shown on drawing title and file number)	13 TOTAL NO OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5 NAME OF DRILLER	14 TOTAL NUMBER CORE BOXES
6 DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG FROM VERT	15 ELEVATION GROUND WATER
7 THICKNESS OF OVERBURDEN	16 DATE HOLE — STARTED — COMPLETED
8 DEPTH DRILLED INTO ROCK	17 ELEVATION TOP OF HOLE
9 TOTAL DEPTH OF HOLE	18 TOTAL CORE RECOVERY FOR BORING %
	19 SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			2.0' STICKUP			
			0.0 SURFACE			
			2.5' TOP GROUT			
	18		18.0' TOP SAND			
			TOP SCREEN			
			33.0' BTM SCREEN			
			35.0 BOH			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) — PROJECT — HOLE NO

Hole No. 186

DRILLING LOG	DIVISION SOUTHWEST	INSTALLATION PINE BLUFF	SHEET 1 OF 2 SHEETS

1 PROJECT: LAND WHITE FILL AREA	10 SIZE AND TYPE OF BIT 4-1/2 Sp Tube
2 LOCATION (Coordinates or Station): SEE PLATS (6-Act C/H/D/I)	11 DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL 305.80
3 DRILLING AGENCY: IJCE	12 MANUFACTURER'S DESIGNATION OF DRILL: CME
4 HOLE NO (As shown on drawing title and file number): 186	13 TOTAL NO OF OVER-BURDEN SAMPLES TAKEN — DISTURBED / UNDISTURBED
5 NAME OF DRILLER: JAMES WYATT	14 TOTAL NUMBER CORE BOXES: NONE
6 DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ____ DEG FROM VERT	15 ELEVATION GROUND WATER
	16 DATE HOLE — STARTED 8-30-83 — COMPLETED 8-30-83
7 THICKNESS OF OVERBURDEN: 35.0'+	17 ELEVATION TOP OF HOLE: 0.0
8 DEPTH DRILLED INTO ROCK: 0.0	18 TOTAL CORE RECOVERY FOR BORING: NONE %
9 TOTAL DEPTH OF HOLE: 35.0	19 SIGNATURE OF INSPECTOR: B.H. Yalana

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0		0.0-17.0' CLAY (CL) Soft to med stiff. Sandy, damp to moist, reddish-brown.			8-30-83 Cum. set Four-inch sp auger to 32.0' wet at 22.0 3 Jar Samples 1-17.0-24.0 2-24.0-27.0 3-27.0-32.0 Mixed revert, 10 In Asbtail to 35.0, 2in down revert set PVC Screen
	10					[illegible] S... 18.0-13.0'
	17.0		SAND, SP- fine to med gr. dense, damp some clay stone; tan wet at 22.0'		17.0 J-1 20.0	SM
	20					
	24.0		CLAY (CL) Sandy, med stiff dark brown damp.		24.0 J-2 27.0	SC-SM
	27.0		SAND. (SC) fine to med gr saturated tan, contains dark. brown. med stiff clay lenses, damp		J-3 32.0	SM
	30					
	32.0					
	35.0		BOH			

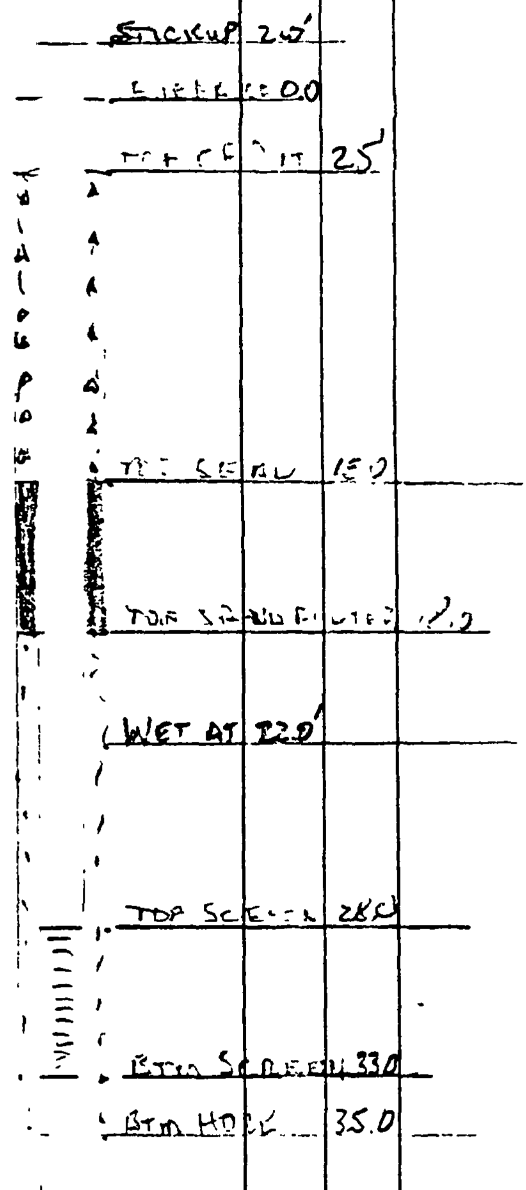
ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) | PROJECT | HOLE NO

Hole No. 126

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1 PROJECT	10 SIZE AND TYPE OF BIT
	11 DATUM FOR ELEVATION SHOWN (TBM or MSL)
2 LOCATION (Coordinates or Station)	12. MANUFACTURER'S DESIGNATION OF DRILL
3 DRILLING AGENCY	13 TOTAL NO OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
4 HOLE NO (As shown on drawing title and file number)	14 TOTAL NUMBER CORE BOXES
5. NAME OF DRILLER	15 ELEVATION GROUND WATER
6 DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ______ DEG FROM VERT	16. DATE HOLE — STARTED — COMPLETED
	17 ELEVATION TOP OF HOLE
7 THICKNESS OF OVERBURDEN	18 TOTAL CORE RECOVERY FOR BORING %
8 DEPTH DRILLED INTO ROCK	19 SIGNATURE OF INSPECTOR
9 TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g



ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT | HOLE NO

Hole No. 187

DRILLING LOG	DIVISION Southwest	INSTALLATION Pine Bluff Arsenal	SHEET 1 OF 2 SHEETS

1. PROJECT: LAND WASTEFILL AREA
2. LOCATION (Coordinates or Station): See drawing
3. DRILLING AGENCY: NCE
4. HOLE NO. (As shown on drawing title and file number): 187
5. NAME OF DRILLER: JAMES WYATT
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 35.0+
8. DEPTH DRILLED INTO ROCK: 0.0
9. TOTAL DEPTH OF HOLE: 35.0
10. SIZE AND TYPE OF BIT: 6 1/4 in. -
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL 304.56
12. MANUFACTURER'S DESIGNATION OF DRILL: CME
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 3 | UNDISTURBED
14. TOTAL NUMBER CORE BOXES: 1, ONE
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 8-30-83 | COMPLETED 8-31-83
17. ELEVATION TOP OF HOLE: -0.4'
18. TOTAL CORE RECOVERY FOR BORING: None %
19. SIGNATURE OF INSPECTOR: [illegible]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0–14.0		CLAY 0.0-14.0 (CL) Soft to med. stiff Sandy damp to moist, reddish-brown			8-30-83 Can ... 6" Sp. auger 0.0' to 35.0' wet at 23.0' end of shift. 8-31-83 Cldy ... 10-in ... to 35.0, using clean water, set 37.0' of 4 in PVC ..., 15.0' screen to 35.0' with 2.0' ... sticking. Sand filter to 12.0' Bentonite seal to 10.0' Grout to 2.5' surface. Moved to Hole 188
	14.0–26.0		SAND SP fine to med grained, damp some clay lenses tan. wet at 23.0	SM	17.5 J-1 18.5	
				SM	23.0 J-2 26.0	
	26.0–35.0		CLAY (SC) med stiff, damp to moist. Sandy, dark brown to reddish brown. Iron stained, from 34.0' to 35.0' B.O.H.	ML, sdy	J-3 35.0	

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE

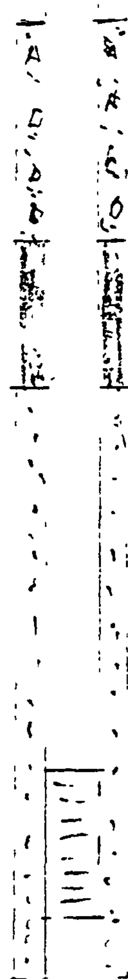
PROJECT: LAND WASTEFILL AREA | HOLE NO. 187

Hole No.

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 2 SHEETS

1 PROJECT	10 SIZE AND TYPE OF BIT
2 LOCATION (Coordinates or Station)	11 DATUM FOR ELEVATION SHOWN (TBM or MSL)
3 DRILLING AGENCY	12 MANUFACTURER'S DESIGNATION OF DRILL
4 HOLE NO (As shown on drawing title and file number)	13 TOTAL NO OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14 TOTAL NUMBER CORE BOXES
6 DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ______ DEG FROM VERT	15 ELEVATION GROUND WATER
	16. DATE HOLE — STARTED — COMPLETED
7 THICKNESS OF OVERBURDEN	17 ELEVATION TOP OF HOLE
8 DEPTH DRILLED INTO ROCK	18 TOTAL CORE RECOVERY FOR BORING %
9 TOTAL DEPTH OF HOLE	19 SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g



2.0' Stickup

0.0 Surface

2.5' Top Grout

10.0' Top Seal

15.0' Filter Sand

23.0' wet

26.0 Top of Clay — water zone

28.0 Top Screen

33.0' Btm Screen

35.0' BoH

Hole No 177

DRILLING LOG	DIVISION [illegible]	INSTALLATION [illegible]	SHEET 1 OF 2 SHEETS

1 PROJECT [illegible]	10 SIZE AND TYPE OF BIT 6" [illegible]
2 LOCATION (Coordinates or Station) [illegible]	11 DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL 364.71
3 DRILLING AGENCY [illegible]	12 MANUFACTURER'S DESIGNATION OF DRILL [illegible]
4 HOLE NO (As shown on drawing title and file number) 177	13 TOTAL NO OF OVER-BURDEN SAMPLES TAKEN — DISTURBED 2 — UNDISTURBED
5 NAME OF DRILLER [illegible]	14 TOTAL NUMBER CORE BOXES None
6 DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED ____ DEG FROM VERT	15 ELEVATION GROUND WATER
	16 DATE HOLE — STARTED 9-1-83 — COMPLETED
7 THICKNESS OF OVERBURDEN 35.0+	17 ELEVATION TOP OF HOLE 0.2+
8 DEPTH DRILLED INTO ROCK 0	18 TOTAL CORE RECOVERY FOR BORING None %
9 TOTAL DEPTH OF HOLE 35.0	19 SIGNATURE OF INSPECTOR [illegible]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			0.0'-21.8 CLAY, soft to med stiff yellow-brown to dark gray damp to moist, yellow-brown to 12.0'			9-1-83 Six-inch spiral auger to 35.0' wet at 24.5' Ten-inch Fishtail to 35.0' end of shift
	10					
	20					
	21.8		21.8 - 28.0, SAND fine damp, dense, tan, wet at 24.5'		21.8 J-1 25.0	SM
	28.0		28.0'-35.0' CLAY Damp, dark gray, med. stiff to stiff sandy [illegible] stiff below 30.0', stiff 28.0 - 30.0'		29.0 J-2 30.0	
	30				J-2	ML, sdy
	35.0				35.0	
	40					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) | PROJECT | HOLE NO 177

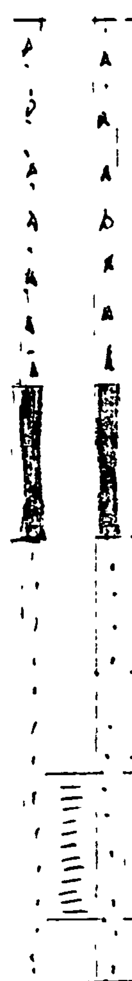
Hole No 17

DRILLING LOG

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 2 SHEETS

1 PROJECT	10 SIZE AND TYPE OF BIT
	11 DATUM FOR ELEVATION SHOWN (TBM or MSL)
2. LOCATION (Coordinates or Station)	12 MANUFACTURER'S DESIGNATION OF DRILL
3 DRILLING AGENCY	13 TOTAL NO OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
4 HOLE NO (As shown on drawing title and file number)	14 TOTAL NUMBER CORE BOXES
5. NAME OF DRILLER	15 ELEVATION GROUND WATER
6 DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ______ DEG FROM VERT	16 DATE HOLE — STARTED — COMPLETED
7 THICKNESS OF OVERBURDEN	17 ELEVATION TOP OF HOLE
8 DEPTH DRILLED INTO ROCK	18 TOTAL CORE RECOVERY FOR BORING %
9 TOTAL DEPTH OF HOLE	19 SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g



2.0' STICKUP

0.0 SURFACE

2.5' TOP GROUT

18.0 TOP SEAL

22.0 TOP FILTER SAND

25.5' WET

28.0' TOP SCREEN

33.0 BTM SCREEN

35.0 BOH

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) | PROJECT | HOLE NO 177

Hole No. 185

DRILLING LOG

DRILLING LOG	DIVISION: SOUTHWEST	INSTALLATION: PINE BLUFF	SHEET OF 2 SHEETS

1 PROJECT: WASTE LANDFILL AREA	10 SIZE AND TYPE OF BIT: 4-in [illegible]
2 LOCATION (Coordinates or Station): [illegible] (6 foot offset)	11 DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL 308.14
3 DRILLING AGENCY: USCL	12 MANUFACTURER'S DESIGNATION OF DRILL: CME
4 HOLE NO (As shown on drawing title and file number): 185	13 TOTAL NO OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 2; UNDISTURBED
5 NAME OF DRILLER: James Wyatt	14 TOTAL NUMBER CORE BOXES: N/A
6 DIRECTION OF HOLE: ☑ VERTICAL ☐ INCLINED ____ DEG FROM VERT	15 ELEVATION GROUND WATER
	16 DATE HOLE: STARTED 8-26-83; COMPLETED 8-29-83
7 THICKNESS OF OVERBURDEN: 38.0+	17 ELEVATION TOP OF HOLE: -0.4'
8 DEPTH DRILLED INTO ROCK: —	18 TOTAL CORE RECOVERY FOR BORING: N/A %
9 TOTAL DEPTH OF HOLE: 38.0	19 SIGNATURE OF INSPECTOR: [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			0.0'-15.0' CLAY			8-26-83 4-in sp. auger 0.0 to 38.0'. Sand at 15.0', wet at 28.0'. Two samples J-1 28-32', J-2 32'-35'. end of shift. 8-29-83 mixed revert, 10-in fishtail to 38.0'. Set 37.0' 4" PVC with 5.0' screen to 36.5' with 0.5' stickup. Washed thru screen to thin revert. Placed sand filter to 14.5', topped to 9.5'. Grout to 2.5'. end of shift. 8-30-83 W.L. at 20.0' from top of pipe at 7:45 AM
	15.0		APPROXIMATE TOP OF SAND			
			15.0'-38.0' SAND.			
	28				28.0	
	30		J-1 28-32 (CL Sandy) CL, sandy wet fine tan		J-1	CL-ML, sdy
	32				32.0	
			J-2 32-35 (CL Sandy) CL Sandy, wet, fine brown		J-2	SM
	35				35.0	

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: WASTE LANDFILL AREA | HOLE NO: 185

Hole No. 175

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1 PROJECT	10 SIZE AND TYPE OF BIT
2 LOCATION (Coordinates or Station)	11 DATUM FOR ELEVATION SHOWN (TBM or MSL)
3 DRILLING AGENCY	12 MANUFACTURER'S DESIGNATION OF DRILL
4 HOLE NO (As shown on drawing title and file number)	13 TOTAL NO OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5 NAME OF DRILLER	14 TOTAL NUMBER CORE BOXES
	15 ELEVATION GROUND WATER
6 DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ______ DEG FROM VERT	16 DATE HOLE — STARTED — COMPLETED
7 THICKNESS OF OVERBURDEN	17 ELEVATION TOP OF HOLE
8 DEPTH DRILLED INTO ROCK	18 TOTAL CORE RECOVERY FOR BORING %
9 TOTAL DEPTH OF HOLE	19 SIGNATURE OF INSPECTOR

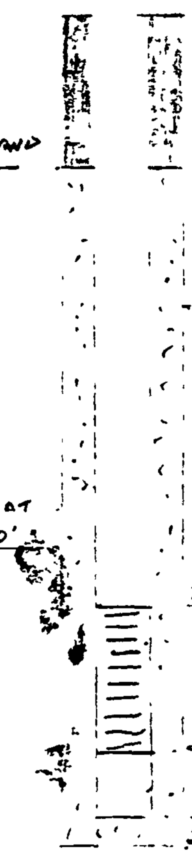
ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g

37.0 Flow well screen

0.5' Stickup
0.0 SURFACE

W

9.5' TOP SEAL



TOP SAND 15

14.5' TOP SAND BACKFILL

W L at 20.0' 8-30-83

WET AT 23.0'

29.5 TOP SCREEN

34.5 BTM SCREEN

36.5 BTM BLANK
39.0 AUN

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT

HOLE NO 185

Hole No. 179

DRILLING LOG	DIVISION [illegible]	INSTALLATION [illegible]	SHEET 1 OF 2 SHEETS

1. PROJECT [illegible]	10. SIZE AND TYPE OF BIT [illegible]
2. LOCATION (Coordinates or Station) [illegible]	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL 302.8C
3. DRILLING AGENCY UJCE	12. MANUFACTURER'S DESIGNATION OF DRILL [illegible]
4. HOLE NO. (As shown on drawing title and file number) 179	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED 2 — UNDISTURBED
5. NAME OF DRILLER [illegible]	14. TOTAL NUMBER CORE BOXES None
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ___ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED 9-7-83 — COMPLETED 9-9-83
7. THICKNESS OF OVERBURDEN 45.0	17. ELEVATION TOP OF HOLE 0.0
8. DEPTH DRILLED INTO ROCK 0.0	18. TOTAL CORE RECOVERY FOR BORING None %
9. TOTAL DEPTH OF HOLE 45.0	19. SIGNATURE OF INSPECTOR [illegible]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			0.0 - 20.0 CLAY very sandy, dry to damp, soft to medium stiff, brownish yellow			9-7-83 Six-inch [illegible] to 45.0' [illegible] 20.0'
	10					9-8-83 [illegible] 6-in [illegible] [illegible] pipe. No [illegible] pipe [illegible] hole [illegible] Indiana
	20		20.0 - 29.0 CLAY med stiff, slightly sandy, damp to moist, reddish-brown.			9-9-83 Fishtail to 40.0' See drawing
	29.0 / 30		SAND 29.0 - 33.0 slightly clayey, fine, moist, dark gray			
			33.0 - 45.0 Clay med. stiff, damp, slightly sandy, dark gray		35.0	
					J-1	CL-ML
					39.?	
	40					

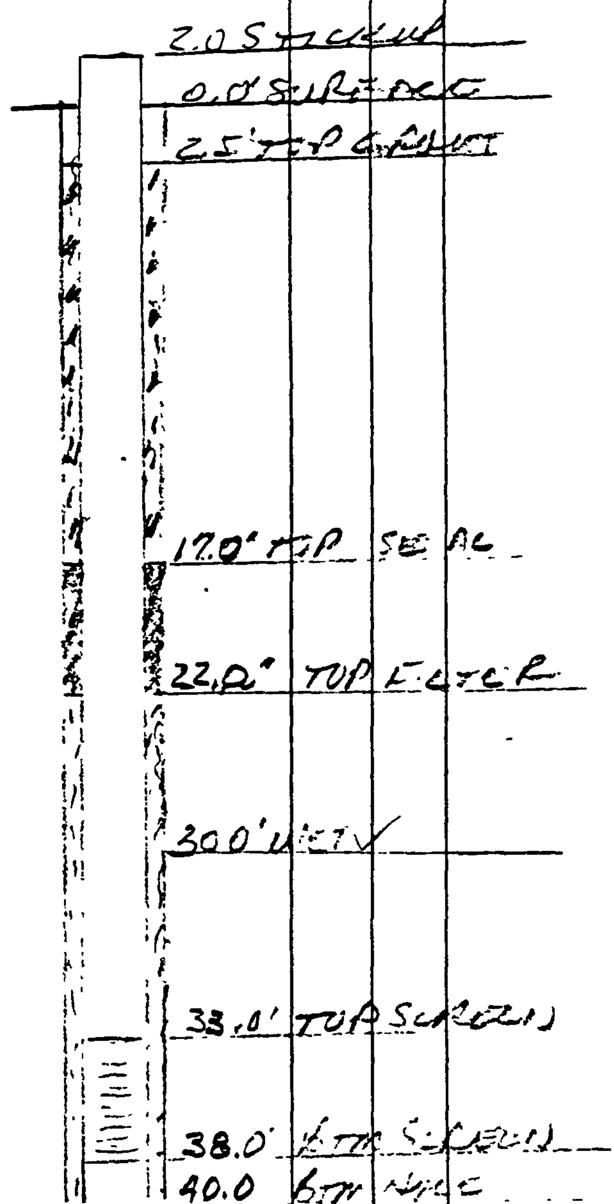
ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) | PROJECT | HOLE NO. 179

Hole No 179

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1 PROJECT	10 SIZE AND TYPE OF BIT
2 LOCATION (Coordinates or Station)	11 DATUM FOR ELEVATION SHOWN (TBM or MSL)
3 DRILLING AGENCY	12 MANUFACTURER S DESIGNATION OF DRILL
4 HOLE NO (As shown on drawing title and file number)	13 TOTAL NO OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5 NAME OF DRILLER	14 TOTAL NUMBER CORE BOXES
	15 ELEVATION GROUND WATER
6 DIRECTION OF HOLE — ☐ VERTICAL ☐ INCLINED ____ DEG FROM VERT	16 DATE HOLE — STARTED — COMPLETED
	17 ELEVATION TOP OF HOLE
7 THICKNESS OF OVERBURDEN	18 TOTAL CORE RECOVERY FOR BORING %
8 DEPTH DRILLED INTO ROCK	19 SIGNATURE OF INSPECTOR
9 TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
					J-1 2.0	CL-ML
	4.5		6 BH.			



ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO 179

(TRANSLUCENT)

Hole No 183

DRILLING LOG	DIVISION Southwest	INSTALLATION Pine Bluff	SHEET 1 OF 1 SHEETS

1 PROJECT Waste Landfill Area	10 SIZE AND TYPE OF BIT [illegible]
2 LOCATION (Coordinates or Station) See [illegible]	11 DATUM FOR ELEVATION SHOWN (TBM or MSL) [illegible] 310.52
3 DRILLING AGENCY [illegible]	12 MANUFACTURER'S DESIGNATION OF DRILL [illegible]
4 HOLE NO (As shown on drawing title and file number) 183	13 TOTAL NO OF OVER-BURDEN SAMPLES TAKEN — DISTURBED 2 — UNDISTURBED
5 NAME OF DRILLER [illegible]	14 TOTAL NUMBER CORE BOXES N/A
6 DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG FROM VERT	15 ELEVATION GROUND WATER
	16 DATE HOLE — STARTED 8-25-83 — COMPLETED 8-27-83
7 THICKNESS OF OVERBURDEN 38.0+	17 ELEVATION TOP OF HOLE +0.3
8 DEPTH DRILLED INTO ROCK 0.0	18 TOTAL CORE RECOVERY FOR BORING N/A %
9 TOTAL DEPTH OF HOLE 38.0	19 SIGNATURE OF INSPECTOR [illegible]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			0.0-6.7' CLAY (CL) sandy, damp soft, tan			8-25-83 10-in auger to 30.0' Two jar samples J-1 30.0-33.5', J-2 33.5'-35.7' end of shift
	8		6.7-10.5' CLAY (CL) v. sandy, damp, soft, light tan			8-26-83 Tape hole to 22.0' bridged, top of sand. Mixed revert, 7 7/8-in RB to 38.0'
			10.5'-15.5' CLAY (CL) Sandy, moist, soft, dark gray			Set 37.0 of 4-in pvc well set with 5' well screen and 2-in [illegible] No stickup Sand backfill
			15.5'-18.5' CLAY (CL) v. sandy, moist, soft, dark brown/red limonite frags.			to 22.0', Bentonite to 17.2, end of shift
	20		18.5'-24.5' (SC) Sandy clay damp, slightly clayey, tan, fine			8-27-83 Tape inside of 4-in pipe Tape to 36.0, Tape to 12.2' outside, Grout from 12.2'-17.2',
			24.5'-38.0' Sand, fine, white-gray, wet at 30.0'			Washed thru screen to 37.0; Tape hole to 36.0; Bailed outside hole to 14.2'. water
			J-1 30.0'-33.5' Sand, fine gr red & gray, saturated.		30.0	level inside and outside of PVC at 9.0'.
			J-2 33.5-35.7' Sand, fine gr brown, saturated.	SM	J-1 33.5	Mixed cement, water and sand, grouted from 14.2' to 2.5'.
	36			SM	J-2 35.7	moved to Hole 182 8-30-83 W.L. 16.4' [illegible]
	38.0		EOH			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT LAND WASTEFILL — HOLE NO 183

Hole No. 123

DRILLING LOG

DIVISION	INSTALLATION	SHEET OF SHEETS

1 PROJECT

2 LOCATION (Coordinates or Station)

3. DRILLING AGENCY

4 HOLE NO (As shown on drawing title and file number)

5 NAME OF DRILLER

6 DIRECTION OF HOLE
☐ VERTICAL ☐ INCLINED ______ DEG FROM VERT

7 THICKNESS OF OVERBURDEN

8 DEPTH DRILLED INTO ROCK

9 TOTAL DEPTH OF HOLE

10 SIZE AND TYPE OF BIT

11 DATUM FOR ELEVATION SHOWN (TBM or MSL)

12 MANUFACTURER'S DESIGNATION OF DRILL

13 TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED

14. TOTAL NUMBER CORE BOXES

15. ELEVATION GROUND WATER

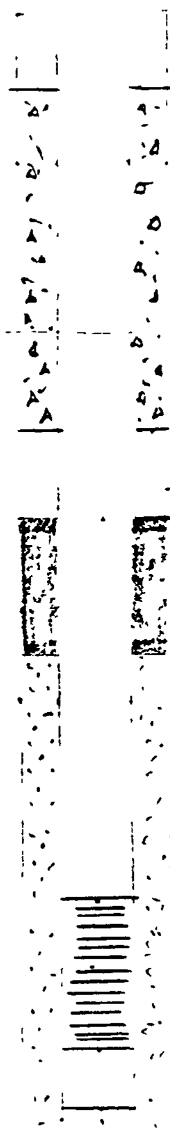
16 DATE HOLE | STARTED | COMPLETED

17 ELEVATION TOP OF HOLE

18 TOTAL CORE RECOVERY FOR BORING %

19 SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g



0 0 Surface

2.5 Top of Grout 8-28-83

W.L at 9.0' in PVC & Outside after surging & bailing outside.

12.2 COS... 12.2 17.2

Top of COUL... at 14.7'

WL at 16.4 8-30-83

Top SEAL AT 17.2'

TOP SAND AT 22.0'

TOP SCREEN 30'

WL @ 32.2 8-29-83 (Before Washing)

Btm Screen 35'

Btm Blank at 37'

38.0 BOH

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE | PROJECT | HOLE NO

(TRANSLUCENT)

Hole No. 181

DRILLING LOG	DIVISION SOUTHWEST	INSTALLATION PINE BLUFF	SHEET 1 OF 2 SHEETS

1 PROJECT WASTE LANDFILL AREA	10 SIZE AND TYPE OF BIT 7"
2 LOCATION (Coordinates or Station) SEE 1 LAW (6 FT OFFSET	11 DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL 302.37
3 DRILLING AGENCY USCE	12 MANUFACTURER'S DESIGNATION OF DRILL FAILING 150D
4 HOLE NO (As shown on drawing title and file number) 181	13 TOTAL NO OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5 NAME OF DRILLER JACK VAN WAGENER	14 TOTAL NUMBER CORE BOXES NONE
6 DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG FROM VERT	15 ELEVATION GROUND WATER
	16 DATE HOLE STARTED 8-30-83 COMPLETED 8-31-83
7 THICKNESS OF OVERBURDEN 45.0'	17 ELEVATION TOP OF HOLE -0.2'
8 DEPTH DRILLED INTO ROCK 0.0	18 TOTAL CORE RECOVERY FOR BORING None %
9 TOTAL DEPTH OF HOLE 45.0	19 SIGNATURE OF INSPECTOR Bill [illegible]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			CLAY (CL) very sandy soft, damp, yellow, brown.			8-30-83 Clean 10-in spiral auger to 42.0' wet at 31.0' 8-31-83 7 7/8" fishtail to 45.0'. Thinned [illegible] and installed 47.0' 4-in PVC with 2 feet stickup. Set 5 foot screen 38.0 - to 43.0. Sand to 27.0' Seal to 22.0', Grout to 2.5' 2.0' Stickup. Moved to Hole 180.
	15					
	17.0		SAND (SC) very clayey tan to yellow, brown. fine grained			
	20					
	24.0		CLAY (CL) soft to med. stiff sandy, damp, dark brown			
	29.0		SAND fine grained slightly clayey damp dark gray			
	30					
	32.0		CLAY (SC) v sandy dark gray soft, damp		32.0	
				SM	J-1	
					36.0	
	40				J-2	

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) PROJECT HOLE NO 181

Hole No. 18

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1 PROJECT	10 SIZE AND TYPE OF BIT
	11 DATUM FOR ELEVATION SHOWN (TBM or MSL)
2 LOCATION (Coordinates or Station)	12 MANUFACTURER'S DESIGNATION OF DRILL
3 DRILLING AGENCY	13 TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
4 HOLE NO. (As shown on drawing title and file number)	14 TOTAL NUMBER CORE BOXES
5 NAME OF DRILLER	15 ELEVATION GROUND WATER
6 DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16 DATE HOLE — STARTED — COMPLETED
	17 ELEVATION TOP OF HOLE
7 THICKNESS OF OVERBURDEN	18 TOTAL CORE RECOVERY FOR BORING %
8 DEPTH DRILLED INTO ROCK	19 SIGNATURE OF INSPECTOR
9 TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			CLAY (SC)			2.5' STICKUP
			CL-ML	J-2		0.0 Surface
						2.5' TOP GROUT
	45		BOH	40.0		
						22.0' TOP SEAL
						27.0' TOP Sand
						38.0' TOP SCREEN
						43.0 Btm SCREEN
						45.0 BOH

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT

HOLE NO. 18

Hole No 180

DRILLING LOG	DIVISION [illegible]	INSTALLATION PINE BLUFF ARSENAL	SHEET 1 OF 2 SHEETS

1 PROJECT: [illegible] AREA	10 SIZE AND TYPE OF BIT [illegible]
2 LOCATION (Coordinates or Station): [illegible]	11 DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL 303.46
3 DRILLING AGENCY: USCE	12 MANUFACTURER'S DESIGNATION OF DRILL: [illegible]
4 HOLE NO (As shown on drawing title and file number): 180	13 TOTAL NO OF OVER-BURDEN SAMPLES TAKEN — DISTURBED: 2 — UNDISTURBED:
5 NAME OF DRILLER: [illegible] VAN [illegible]	14 TOTAL NUMBER CORE BOXES: None
6 DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15 ELEVATION GROUND WATER
	16 DATE HOLE — STARTED: 9-1-83 — COMPLETED: 9-1-83
7 THICKNESS OF OVERBURDEN: 45.0	17 ELEVATION TOP OF HOLE: 0.4'
8 DEPTH DRILLED INTO ROCK: [illegible]	18 TOTAL CORE RECOVERY FOR BORING: None %
9 TOTAL DEPTH OF HOLE: [illegible]	19 SIGNATURE OF INSPECTOR: [illegible]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			0.0-12.0 CLAY Med stiff, sandy, damp, red-brown			Six inch SP auger to 45.0' wet at 34.0 2-Jar Samples [illegible] to 45.0' [illegible]. [illegible] installed [illegible] PVC pipe to 45.0' with 20' [illegible]
	10					
	12.0		12.0'-17.0' CLAY. Very sandy moist tan, soft. moist to [illegible] 24.0' Brown, med. stiff at 26.0			
	20					
	30					
	34.0		34.0-45.0' CLAY. V sandy, dark gray, moist. wet at 34.0' med stiff		35.0 J-1 37.0 J-2	CL-ML
	40					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) | PROJECT | HOLE NO 180

Hole No 18C

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1 PROJECT	10 SIZE AND TYPE OF BIT
2 LOCATION (Coordinates or Station)	11 DATUM FOR ELEVATION SHOWN (TBM or MSL)
3 DRILLING AGENCY	12 MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO (As shown on drawing title and file number)	13 TOTAL NO OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6 DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG FROM VERT	15 ELEVATION GROUND WATER
	16 DATE HOLE — STARTED — COMPLETED
7 THICKNESS OF OVERBURDEN	17 ELEVATION TOP OF HOLE
8 DEPTH DRILLED INTO ROCK	18 TOTAL CORE RECOVERY FOR BORING %
9 TOTAL DEPTH OF HOLE	19 SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Stiff dark gray below 40.0'. damp		J-2 47.0	CL-ML
	45.0		E.O.H.			

20' Stickup

0.0' Surface

-2.0' Top Grout

22.0 Top Seal

27.0' Top Sand

34.0' WET

TOP SCREEN

BTM SCREEN

45.0 BTM HOLE

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT	HOLE NO

Hole No 178

DRILLING LOG | DIVISION: Southwest | INSTALLATION: Pine Bluff Arsenal | SHEET 1 of 2 SHEETS

1. PROJECT: Land Waste Fill Area
2. LOCATION (Coordinates or Station): See plan & field offset
3. DRILLING AGENCY: USCE
4. HOLE NO (As shown on drawing title and file number): 178
5. NAME OF DRILLER: James Wyatt
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ____ DEG FROM VERT
7. THICKNESS OF OVERBURDEN: 45.0+
8. DEPTH DRILLED INTO ROCK: 0.0
9. TOTAL DEPTH OF HOLE: 45.0+
10. SIZE AND TYPE OF BIT: 6-in auger - 10-in
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL 304.61
12. MANUFACTURER'S DESIGNATION OF DRILL: CME
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 2 | UNDISTURBED
14. TOTAL NUMBER CORE BOXES: None
15. ELEVATION GROUND WATER:
16. DATE HOLE: STARTED 9-7-83 | COMPLETED 9-9-83
17. ELEVATION TOP OF HOLE: 0.0
18. TOTAL CORE RECOVERY FOR BORING: None %
19. SIGNATURE OF INSPECTOR: [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			0.0-23.0 CLAY CL, very sandy, dry to damp, soft to medium soft, brownish-yellow.			9-7-83 Six-inch auger to 45.0' Water at 34.0' J-jar samples end 1st ft. 9-8-83 Fishtail 10-in to 45.0' Backfilled piez in landfill waste area limits Pressure grouted 88.0' 1 1/4" take 1.25 CF. Backfilled with hole at bottom 84.0' take 1.5 CF. Started backfilling with base 3/4" to bottom of hole, No 10-foot PVC 4-in having to wait on the order to arrive. W.L. 9-8-83 12.3'
	23.0		23.0'-30.0' CLAY CL slightly sandy, damp to moist, medium stiff, reddish-brown.		30.0	
	30.0		SAND, slightly clayey, soft, fine, moist, dark gray.	SM	J-1 34.0	
	34.0		CLAY, CL, slightly sandy, medium stiff, moist, dark gray	ML	J-2 39.0	

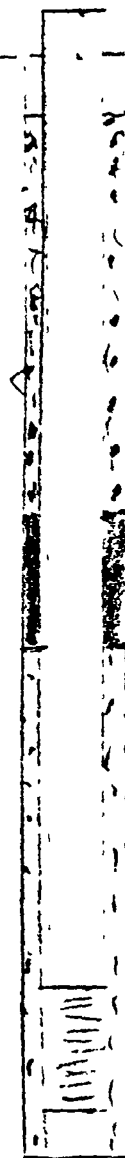
ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) | PROJECT | HOLE NO 178

Hole No 178

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 2 SHEETS

1 PROJECT	10 SIZE AND TYPE OF BIT
	11 DATUM FOR ELEVATION SHOWN (TBM or MSL)
2 LOCATION (Coordinates or Station)	12 MANUFACTURER'S DESIGNATION OF DRILL
3 DRILLING AGENCY	13 TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
4 HOLE NO (As shown on drawing title and file number)	14 TOTAL NUMBER CORE BOXES
5. NAME OF DRILLER	15 ELEVATION GROUND WATER
6 DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT	16 DATE HOLE — STARTED — COMPLETED
7 THICKNESS OF OVERBURDEN	17 ELEVATION TOP OF HOLE
8 DEPTH DRILLED INTO ROCK	18 TOTAL CORE RECOVERY FOR BORING %
9 TOTAL DEPTH OF HOLE	19 SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g



2.0' STICKUP

0.0 SURFACE

2.5' TOP GROUT

19.0' TOP SEAL

24.0' TOP FILTER

34.0' WET

TOP SCREEN 38.0'

BTM SCREEN 43.0'

BTM HOLE 45.0'

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT

HOLE NO 178

PRE-SCORE

REFERENCE 10

PREFACE

U.S. DEPARTMENT OF COMMERCE
Luther H. Hodges, Secretary

WEATHER BUREAU
F. W. Reichelderfer, Chief

TECHNICAL PAPER NO. 40

RAINFALL FREQUENCY ATLAS OF THE UNITED STATES

for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years

Prepared by
DAVID M. HERSHFIELD
Cooperative Studies Section, Hydrologic Services Division
for
Engineering Division, Soil Conservation Service
U.S. Department of Agriculture

THIS ATLAS IS OBSOLETE FOR THE FOLLOWING 11 WESTERN STATES. Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.

NOAA ATLAS 2: PRECIPITATION-FREQUENCY ATLAS OF THE WESTERN UNITED STATES (GPO: 11 Vols., 1973) supersedes the Technical Paper 40 data for these states

All but 3 of the 11 state volumes are out of print, and no reprint is presently planned.

Institutions in the eleven western states likely to have copies of these volumes for their state for public inspection are.

US Department of Agriculture Soil Conservation Service Offices
US Army Corps of Engineers Offices
Selected University Libraries
National Weather Service Offices (may also have volumes for adjacent states).
National Weather Service Forecast Offices (may have all eleven volumes)

Elsewhere, libraries of universities where hydrology and meteorology degree programs are offered may shelve some of the eleven volumes.

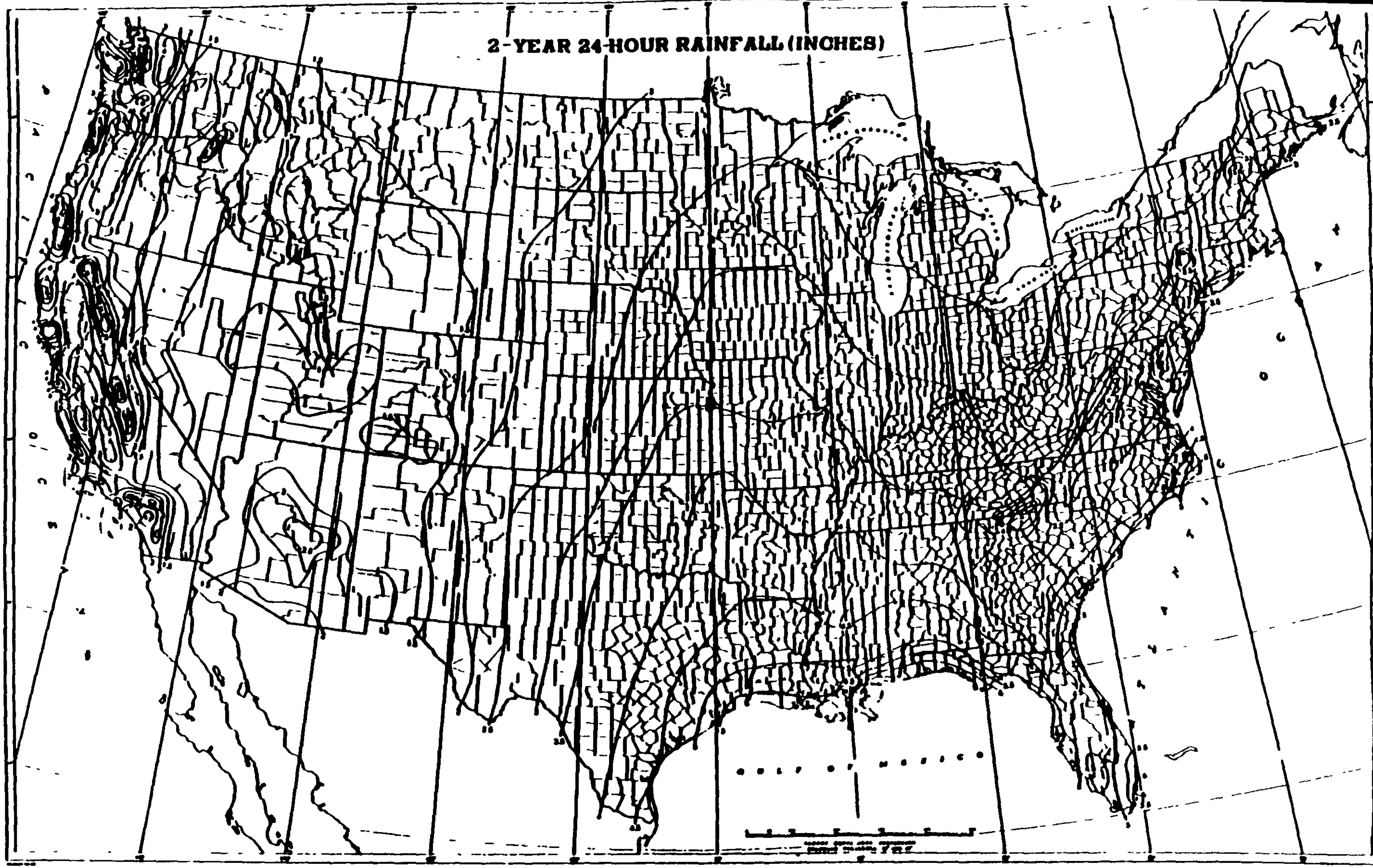
The three volumes in print as of 1 Jan 1983 at the GPO are

Vol	State	GPO Stock Number	Price
IV	New Mexico	003 017 00158 0	$10 00
VI	Utah	003 017 00160 1	12 00

NOTICE

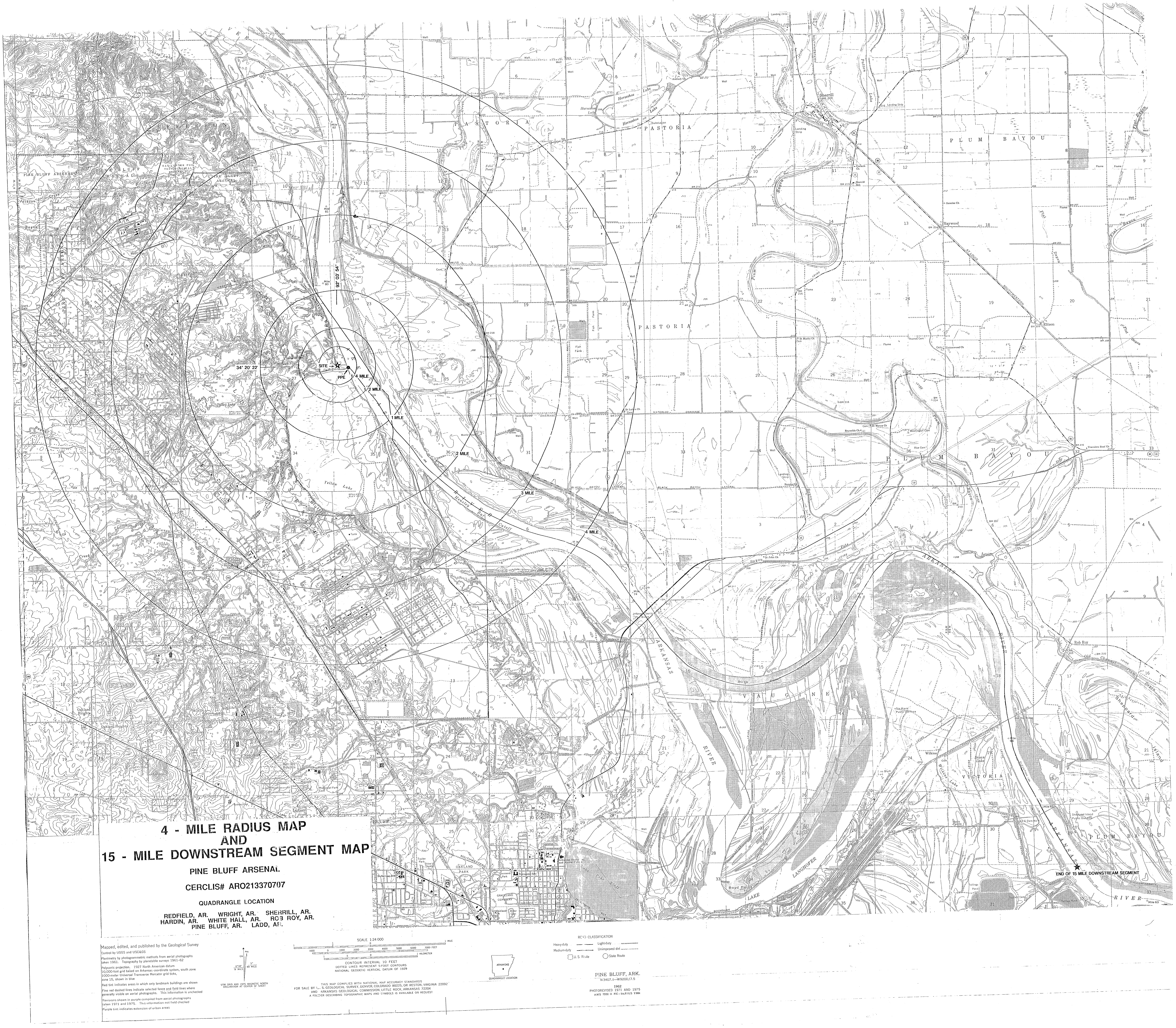
Rainfall frequency information for durations of 1 hour and less for the Central and Eastern States has been superseded by NOAA Technical Memorandum NWS HYDRO 35 Five to Sixty-Minute Precipitation Frequency for the Eastern and Central United States. This publication (Accession No. PB 272 112/AS) is obtainable from

National Technical Information Service
5285 Port Royal Road
Springfield VA 22161


2-YEAR 24-HOUR RAINFALL (INCHES)
GULF OF MEXICO

PRE-SCORE

REFERENCE 11


4 - MILE RADIUS MAP
AND
15 - MILE DOWNSTREAM SEGMENT MAP
PINE BLUFF ARSENAL
CERCLIS# ARO213370707
QUADRANGLE LOCATION
REDFIELD, AR. WRIGHT, AR. SHERRILL, AR.
HARDIN, AR. WHITE HALL, AR. ROB ROY, AR.
PINE BLUFF, AR. LADD, AR.
SITE
PPE
1/4 MILE
1/2 MILE
1 MILE
2 MILE
3 MILE
4 MILE
34° 20' 22"
92° 03' 54"
END OF 15 MILE DOWNSTREAM SEGMENT
PASTORIA
PLUM BAYOU
VAUGINE
VICTORIA
Sherrill
Rob Roy
ARKANSAS RIVER
Mapped, edited, and published by the Geological Survey
Control by USGS and USC&GS
Planimetry by photogrammetric methods from aerial photographs taken 1961. Topography by planetable surveys 1961-62
Polyconic projection. 1927 North American datum
10,000-foot grid based on Arkansas coordinate system, south zone
1000-meter Universal Transverse Mercator grid ticks, zone 15, shown in blue
Red tint indicates areas in which only landmark buildings are shown
Fine red dashed lines indicate selected fence and field lines where generally visible on aerial photographs. This information is unchecked
Revisions shown in purple compiled from aerial photographs taken 1971 and 1975. This information not field checked
Purple tint indicates extension of urban areas
UTM GRID AND 1975 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET
SCALE 1:24 000
CONTOUR INTERVAL 10 FEET
DOTTED LINES REPRESENT 5-FOOT CONTOURS
NATIONAL GEODETIC VERTICAL DATUM OF 1929
THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092
AND ARKANSAS GEOLOGICAL COMMISSION, LITTLE ROCK, ARKANSAS 72204
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST
ROAD CLASSIFICATION
Heavy-duty
Light-duty
Medium-duty
Unimproved dirt
U. S. Route
State Route
ARKANSAS
QUADRANGLE LOCATION
PINE BLUFF, ARK.
N3407.5—W9200/7.5
1962
PHOTOREVISED 1971 AND 1975
AMS 7552 II NE—SERIES V884

PRE-SCORE

REFERENCE 12

Water Resources Data Arkansas Water Year 1990

U.S. GEOLOGICAL SURVEY WATER-DATA REPORT AR-90-1
Prepared in cooperation with the Arkansas Department of Pollution Control and Ecology; Arkansas Game and Fish Commission; Arkansas Geological Commission; Arkansas Soil and Water Conservation Commission; Arkansas State Highway and Transportation Department; Independence County; Little Rock Municipal Water Works;

07263706 ARKANSAS RIVER AT LOCK AND DAM 4 NEAR PINE BLUFF, ARKANSAS

LOCATION --Lat 34°14'56", long 91°54'22", in SE ¼ NE ¼ sec.29, T.5 S., R.5 W., Jefferson County, Hydrologic Unit 11110207, on upstream side of lock and dam at end of State Highway 81, 2.2 mi east of St. Louis Southwestern Railroad Yard.

DRAINAGE AREA.--158,542 mi², of which 22,241 mi² is probably noncontributing.

PERIOD OF RECORD.--November 1983 to current year.

COOPERATION.--Records were furnished by Arkansas Department of Pollution Control and Ecology, Little Rock, Ark

WATER QUALITY DATA, WATER YEAR OCTOBER 1989 TO SEPTEMBER 1990

DATE	TIME	AGENCY COL-LECTING SAMPLE (CODE NUMBER) (00027)	AGENCY ANA-LYZING SAMPLE (CODE NUMBER) (00028)	DIS-CHARGE, IN CUBIC FEET PER SECOND (00060)	PH (STAND-ARD UNITS) (00400)	TEMPER-ATURE WATER (DEG C) (00010)	TUR-BID-ITY (NTU) (00076)	OXYGEN, DIS-SOLVED (MG/L) (00300)	OXYGEN DEMAND, BIO-CHEM-ICAL, 5 DAY (MG/L) (00310)
OCT									
02...	1000	9827	9827	31700	8.1	20.0	--	8.5	1.2
31 ..	1000	9827	9827	15700	8.5	18.0	5.4	9.5	1.6
DEC									
05 ..	0940	9827	9827	2020	8.2	10.0	3.6	10.9	1.4
JAN									
16...	0953	9827	9827	100	8.4	7.0	3.5	12.8	2.8
FEB									
27 ..	1025	9827	9827	73700	7.0	10.0	--	11.2	1.3
MAR									
13...	0820	9827	9827	164000	7.7	15.0	--	9.9	1.9
APR									
10...	1240	9827	9827	177000	7.8	15.0	55	10.1	0.6
SEP									
04...	1535	9827	9827	4200	8.9	32.0	--	9.5	2.9
18...	0945	9827	9827	2500	8.6	27.0	--	8.5	3.7

7=

Total 470,930 ÷ 52,324

DATE	TIME	HARD-NESS TOTAL (MG/L AS CACO3) (00900)	SULFATE DIS-SOLVED (MG/L AS SO4) (00945)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL) (00940)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L) (70300)	RESIDUE TOTAL AT 105 DEG. C, SUS-PENDED (MG/L) (00530)	NITRO-GEN, NO2+NO3 TOTAL (MG/L AS N) (00630)	NITRO-GEN, AMMONIA TOTAL (MG/L AS N) (00610)	NITRO-GEN, AM-MONIA + ORGANIC TOTAL (MG/L AS N) (00625)
OCT									
02.	1000	140	59	80	400	--	0.350	0.050	0.76
31. .	1000	140	--	--	335	8	--	<0.050	0.45
DEC									
05...	0940	160	53	130	437	7	0.120	0.070	1.1
JAN									
16...	0953	160	62	110	--	8	<0.020	<0.050	0.82
FEB									
27...	1025	90	35	55	228	25	--	<0.050	1.8
MAR									
13.	0820	96	38	61	233	46	0.320	<0.050	0.67
APR									
10...	1240	110	36	48	245	45	0.500	0.050	1.1
SEP									
04...	1535	130	45	62	277	10	<0.020	--	0.90
18...	0945	130	39	65	283	9	--	0.110	0.87

DATE	TIME	PHOS-PHORUS TOTAL (MG/L AS P) (00665)	PHOS-PHORUS ORTHO TOTAL (MG/L AS P) (70507)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD) (01027)	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR) (01034)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU) (01042)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB) (01051)	ZINC, TOTAL RECOV-ERABLE (UG/L AS ZN) (01092)	CARBON, ORGANIC TOTAL (MG/L AS C) (00680)
OCT									
02...	1000	0.140	0.060	--	<1	<15	7	<10	--
31...	1000	0.070	0.050	<1	1	<15	<2	<10	4.7
DEC									
05...	0940	0.150	0.030	<1	<1	16	<2	<10	12
JAN									
16...	0953	0.060	<0.030	--	--	--	--	--	4.7
FEB									
27 .	1025	0.130	0.030	--	--	--	--	--	5.2
MAR									
13...	0820	0.180	0.050	--	--	--	--	--	7.2
APR									
10 ..	1240	0.190	0.060	--	--	--	--	--	7.4
SEP									
04...	1535	0.060	0.080	--	--	--	--	--	7.2
18 ..	0945	0.150	0.130	--	--	--	--	--	5.5

PRE-SCORE

REFERENCE 13

US Army Corps
of Engineers

Tulsa District

PINE BLUFF ARSENAL

SITE 12

MUSTARD BURN PITS

SITE CLOSURE PLAN

JULY, 1985

PINE BLUFF ARSENAL
SITE 12
MUSTARD BURN PITS

SITE CLOSURE PLAN

DEPARTMENT OF THE ARMY
TULSA DISTRICT, CORPS OF ENGINEERS
OKLAHOMA

July, 1985

PINE BLUFF ARSENAL
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SYNOPSIS

Site 12, the Mustard Burn Pits at Pine Bluff Arsenal, Arkansas, will be closed in a FY 86 Military Construction, Army (MCA) project in accordance with all applicable State and Federal regulations. The general investigative procedures followed at Site 12 were to establish the extent and nature of contamination of waste materials both on the surface and in the underlying soils. This included investigations sufficient in scope to determine the vertical and horizontal limits of contaminants present and also to determine if the contaminants would classify as hazardous waste. This contamination consists of heavy metals associated with residue from past burning of mustard agent ordnance. Neither the surface waste nor subsurface materials at Site 12 classify as hazardous waste, therefore, the site closure is not subject to RCRA regulations, if wastes are relocated. Concentrations of contaminants in groundwater samples did not exceed water quality standards.

Additional investigations were made to determine the most effective means of closure that would satisfy the requirements for final disposal of waste materials at the site. The subsurface investigations conclude that a low-permeable clay layer underlies part of the site and is a suitable lower boundary for an in situ encapsulation of the waste materials. Utilization of on-site encapsulation requires moving a significant portion of the waste material. A more economical closure plan consists of moving all contaminated material (15,500 cubic yards) to Site 23A, where fill material is needed in order to complete the Site 23A closure cell. The plan has an estimated cost of $340,200 and is considered to be the most economical and environmentally acceptable alternative, based on the data presented in the following narrative.

I - GENERAL

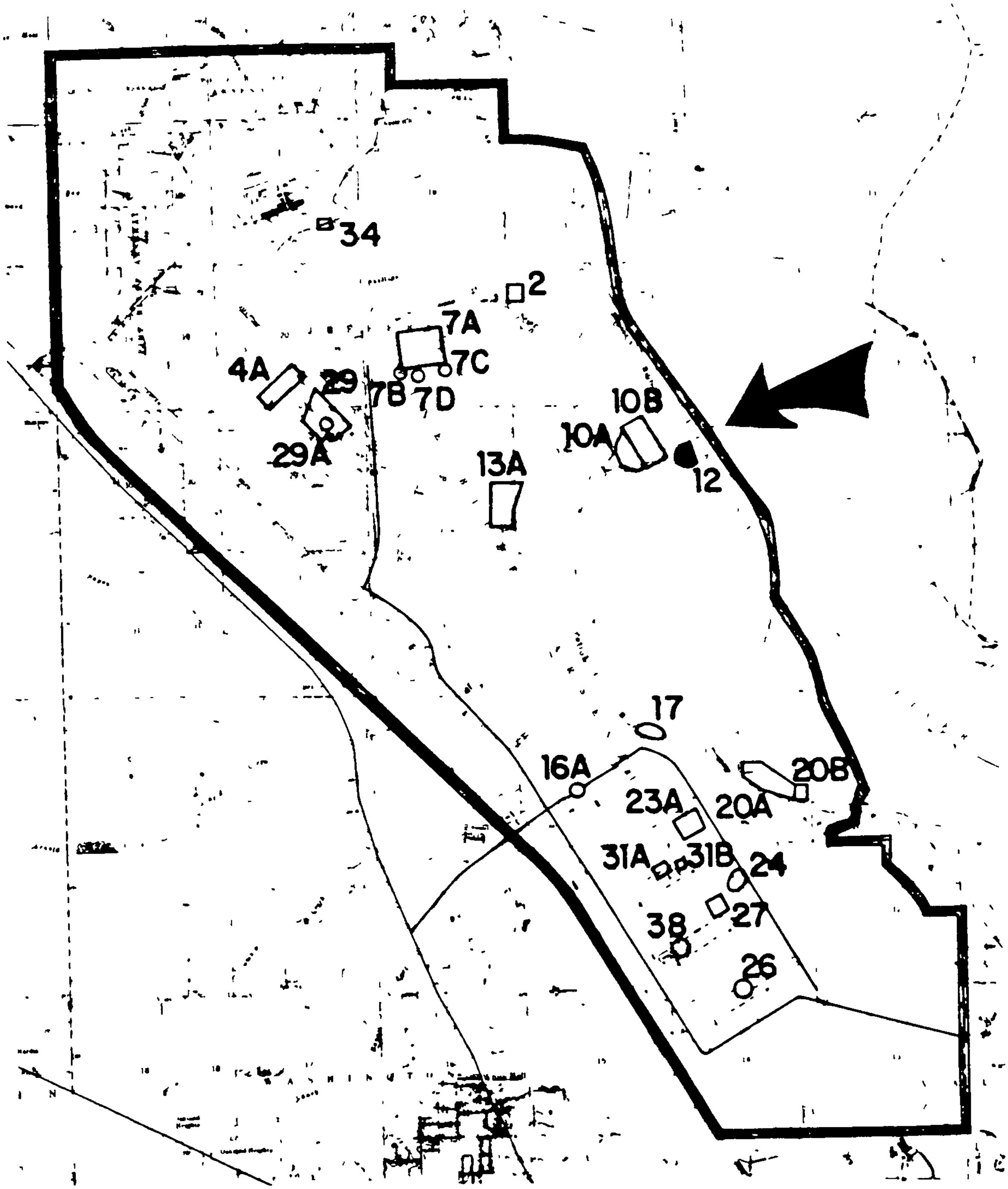
1-01. Purpose. This report presents the closure plan for contaminated waste materials located at Site 12, Mustard Burn Pits at Pine Bluff Arsenal, Arkansas. This site is an inactive site and will be permanently closed in accordance with applicable State and Federal regulations. Closure of this site is required to eliminate a historical open dump and prevent contamination of the waters of the State of Arkansas. Discussions between Arkansas Department of Pollution Control and Ecology (ADPC&E), Tulsa District Corps of Engineers (TDCE), and Pine Bluff Arsenal (PBA) personnel determined that remedial action must be conducted at this site in response to a consent order issued to PBA by the ADPC&E. It was jointly decided to use a negotiation process between the parties similar to the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). Criteria for hazardous waste set forth in the Resource Conservation and Recovery Act (RCRA) were used to classify materials and manage wastes which will become subject to RCRA during the remedial action process. Cleanup limits for RCRA-listed metal contaminants were dictated by ADPC&E and related to both total ion and EP toxicity testing (See table 3-1).

1-02. Report Format. A site description is presented in Section II. The geotechnical and contaminant investigations which form the basis for the proposed closure plan are contained in Section III. A description of the proposed closure plan for this site is presented in Section IV. The indicated closure plan is considered to be the most technically feasible, cost effective, and environmentally acceptable alternative based on the results of geotechnical and contaminant investigations, alternative design studies and existing site conditions. Alternative closure plans studied and comparative cost estimates are presented in Sections V and VI, respectively.

II - SITE DESCRIPTION

2-1. Site Description. Site 12, the Old Mustard Dump Yard, is a 25 acre site located east of the Bombing Mat on Doolittle road. The site was primarily used as a burn and disposal area for mustard munitions. The Arsenal used this site for a period of approximately 6 years. Last known activities were completed in 1948. Scattered across the site are mounds and trenches which are the result of the disposal operations. Four parallel trenches on the southern end of the site contain rusted munitions and 55-gallon drums. A larger pile of debris exists west of the four trenches where shell casings were stacked and burned with thermite. A smaller pile is present south of the four trenches. A large burning area located in the central portion of the site covers approximately one acre. Ash and debris is scattered over the burned ground and a heavy cover of grass now masks much of the area. Pits on the northern end of the site contain the remains of tubes which held igniter mix for the munitions. A smaller burn area in the northern portion of the site covers about 10,000 square feet.

The site is adjacent to the Arkansas River and is relatively flat at approximate elevation 218, just below the 100-year flood elevation of 220.3. Grass, heavy underbrush, and trees now cover the site. An aerial photograph taken in 1961 of the site is presented as photograph 1 in Appendix I. Photos of the debris and rubble taken in 1984, are also presented in Appendix I. Figure 2-1 indicates the location of the site on the Arsenal.



PINE BLUFF ARSENAL

CLOSURE SITES

FIGURE 2 - 1

III - GEOTECHNICAL AND CONTAMINANT INVESTIGATIONS

3-01. Introduction. The purpose of the exploration program was to (1) define subsurface conditions at the site and (2) define the type, severity, and lateral and vertical extent of contamination.

3-02. Field Investigations.

a. Preliminary. Prior to the recent investigation at Site 12, 49 holes were drilled at the site for the 1973-1975 Contaminated Area Survey Project and sampled to a depth of 17.5 feet. The samples were tested for heavy metals and other contaminants. In 1982, one upgradient and 3 downgradient monitoring wells were installed to monitor groundwater at the site. The wells are regularly tested by the Army Environmental Hygiene Agency for selected parameters. The groundwater data from these wells are available on STORET, a computer system administered by the Environmental Protection Agency. Laboratory classifications on the contaminated area survey project borings were not made. However, soil samples from the monitoring well borings were classified according to the Unified Soil Classification System.

b. Current Investigations. Fifty-six auger holes 5 to 15 feet deep, and one denison hole 15 feet deep, were drilled in 1984 and early 1985. In addition eight test pits were dug in the disposal trenches and munitions piles since drilling was impractical due to the presence of metal litter. Water samples were taken from holes when groundwater was encountered and from standing water in pits. Locations of the borings and test pits are shown on drawing 1. Soil from the auger holes was described in the field and classified in the laboratory. Each run of the auger was limited to 3 feet. To prevent mixing of materials, or sampling material that had pulled off from the wall of the hole, only the interior of each sample was used. Material was taken from the entire length of the sample, sealed in plastic jars and shipped to the Corps of Engineers Southwestern Division Laboratory in Dallas. Soil from the denison hole was also described in the field. Six undisturbed (denison) samples were sealed and shipped to the Corps of Engineers Southwestern Division Laboratory for falling-head permeability tests. Those holes which penetrated a clay layer were backfilled with grout.

3-03. Laboratory Testing. Laboratory testing of samples from Site 12 was performed by the Corps of Engineers Southwestern Division (SWD) Laboratory in Dallas, Texas and by local laboratories contracted by them. Results of laboratory testing are reported in Appendix II.

a. Chemical Testing Procedures.

(1) Metals

(i) Total ion testing. Soil samples were digested in strong acid and the resulting extracts were tested by atomic absorption spectroscopy techniques. The acid treatment resulted in total ion extraction, freeing the metals from the soil and pore water. A representative portion of the sample was oven dried and the values reported in milligrams/kilogram (mg/kg) dry weight. Tests were conducted for arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver concentrations (the eight RCRA-listed toxic heavy metal contaminants). In addition zinc concentrations were determined because of its suspected presence at the site, even though it is not a RCRA listed contaminant. Groundwater samples were filtered in the lab and given a similar acid treatment. The results are reported in milligrams/liter (mg/l).

(ii) EP toxicity testing. Extraction procedure methodology, commonly referred to as EP toxicity testing, is a much less rigorous extraction of metals, designed to simulate typical leaching conditions in a landfill. Results are reported in mg/l (as a concentration in an extract obtained in a specified manner). EP toxicity tests were performed on both soil and fill samples from Site 12.

(2) Organics. No testing for organic compounds was performed at Site 12 because none were suspected to be present at the site.

(3) Sulfur. Sulfur analyses were made to relate contamination to the areas where mustard disposal took place. Analyses were performed by direct combustion with a Leco sulfur analyzer.

(4) Mustard Screening. Samples of soil or fill (holes 12-2, 12-5, and 12-6) having appearance or odor similar to material from Site 7C, the Mustard Burn Yard, were tested at the Pine Bluff Arsenal product assurance lab before they were released. These samples did not contain any Agent Mustard.

b. Laboratory Soil Classification. Atterberg limits, sieve analysis, and natural water content tests were performed on selected soil samples. The resulting classifications, based on the Unified Soil Classification System, are used to identify material types. Laboratory visual classifications were used to verify field classifications.

c. Laboratory Permeability Test. One falling head permeability test was performed on a specimen cut from undisturbed (denison) sample of high plasticity clay.

3-04. Stratigraphic Results.

a. General. Site 12 is located within the present floodplain of the Arkansas River at approximate elevation 218. Figure 3-1 is a map of the geologic environments at Pine Bluff Arsenal showing the location of the site. Geologic sections across the site are presented on drawing 2.

b. Alluvial Deposits. Alluvial deposits at the site are silts and clays. There is a considerable amount of high plasticity clay near the surface over the northern two-thirds of the site. Approximately 5 feet of silt or silty clay overlie the clay. This clay layer has an average liquid limit of 49, a plasticity index varying between 20 and 40 and a permeability of 2.7×10^{-8} cm/sec. Horizontal extent of the clay is shown on drawing 3.

c. Water Table. The water table at the site is nearly flat at approximate elevation 201, 17 feet below the ground surface. The gradient is both south (in the direction of flow in the river) and east (toward the Arkansas River).

3-05. Analysis.

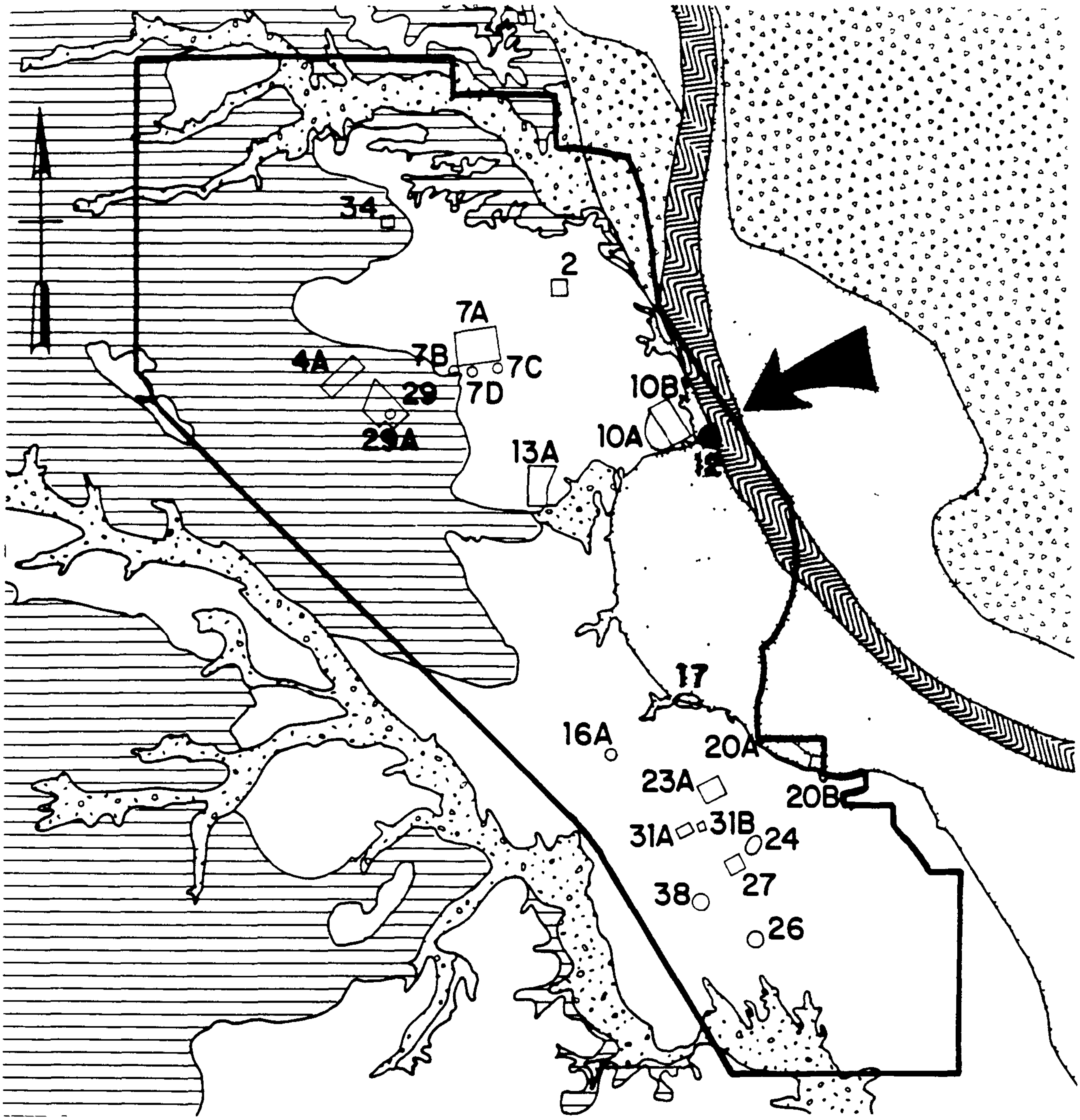
a. Contamination Background Levels and Cleanup Limits. A consent agreement between the ADPC&E and PBA is the basis for this remedial action. This agreement is predicated on Arkansas law which prohibits pollution of Arkansas waters but does not identify contaminants or allowable limits. Through discussions and letters, the ADPC&E identified parameters and concentrations of concern as follows:

(1) Heavy Metals.

(i) Total ion concentrations. The maximum contaminant levels (MCL) for the 8 heavy metals listed in RCRA (40 CFR 261.24) were set at 10 times the background levels. "Arsenal-wide" background levels were calculated as the mean of 102 samples collected in uncontaminated areas near 17 of the sites.

(ii) EP toxicity concentrations. In addition to meeting the MCL for the total ion method, the ADPC&E also required that the samples not exceed one-tenth the regulatory values shown in RCRA (40 CFR 261.24) when analyzed using EP methodology. Table 3-1 lists background levels and MCL's (cleanup limits) for these heavy metals.

(2) Organics. A GC-mass-spectrometer scan was conducted on samples from those sites where there is evidence of disposal of organic compounds. At those sites where the tests revealed the presence of compounds listed in RCRA (40 CFR 261.33), an individual determination of the substance hazard was made. This was dependent on the compounds and the amount present in the sample. This determination was used to develop the recommended closure



ARKANSAS RIVER

ARKANSAS RIVER DEPOSITS

TERRACE

BACKSWAMP

ALLUVIUM

RECENT ALLUVIUM

JACKSON GROUP

GEOLOGIC ENVIRONMENTS

SCALE IN FEET

2000 0 2000 4000

FIGURE 3-1

plan and is subject to approval of the ADPC&E. The organic compounds of primary concern are not naturally occurring, therefore, no organic testing was conducted on background samples collected in uncontaminated areas.

TABLE 3-1

HEAVY METAL BACKGROUND LEVELS AND CLEANUP LIMITS

Contaminant	Background Mean (mg/kg)	Site Cleanup Limits Total Ion MCL (mg/kg)	Site Cleanup Limits EP Toxicity MCL (mg/l)
Arsenic (As)	1.3	13.0	0.5
Barium (Ba)	28.7	290.0	10.0
Cadmium (Cd)	< 0.5	5.0	0.1
Chromium (Cr)	< 5.0	50.0	0.5
Lead (Pb)	7.55	75.5	0.5
Mercury (Hg)	< 0.1	1.0	0.02
Selenium (Se)	0.18	1.8	0.1
Silver (Ag)	< 0.5	5.0	0.5
Zinc (Zn) (1)	8.5	(1)	(1)

(1) Background level for zinc was determined since it is a common constituent of demilitarized ordnance wastes. Zinc is not a RCRA-listed contaminant, therefore, cleanup limits were not required by ADPC&E.

b. Determining Extent of Metal Contamination. As shown on drawing 1, shallow auger holes were drilled in locations where contaminants would be concentrated (low areas, ditches, culverts, and burn areas). Samples from holes 12-2, 12-3, and 12-6, taken from separate burn pits, were tested for arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver, sulfur, zinc, and pH. Arsenic, barium, cadmium, chromium, and lead were found to be the primary contaminants and were selected for further testing. The depth to which the soil would be cleaned up at Site 12 was determined by comparing the measured values of each contaminant with the cleanup values presented in table 3-1. These data are presented graphically for each boring in Appendix III. With the results plotted in this manner, the depth of contamination is easily determined. The limits of contamination (as determined by total ion criteria) were checked with EP toxicity tests to insure that the limits of cleanup would not leave material which exceeded the cleanup limit for EP toxicity. Results were discussed in paragraph 3-05 d.

c. Determining Presence of Mustard and Mustard Byproducts. Samples from holes 12-2, 12-5, and 12-6 were tested for presence of mustard or mustard byproducts. No mustard was found in any of the samples. Mustard byproducts were detected in samples from holes 12-2 (a pit) and 12-6 (a burn area).

d. Surface Debris. Pits and trenches southwest of the southern burn area (geologic section C-C, drawing 2) are filled with 100 and 500 pound mustard shell casings and 55 gallon drums. The agent and igniter rods were removed from these rounds, and they were then burned with thermite. Soil contamination around the rounds is minor and was caused by the thermite burning, not agent spillage. Igniter rods, after removal of the starter mix, were disposed of in pits near the northern burn area.

e. Contamination Results.

(1) Fill and Underlying Soil (Total Ion Results). Approximately four acres of Site 12 are covered with fill material or contaminated soil. The majority of fill is burned residue from various types of disposal operations. The exception to this is the "fill" in the pit at hole 12-2. This fill is black and cindery, very similar in appearance and odor to the demilitarized mustard at Site 7C. Mustard byproducts and high concentrations of sulfur were detected in this fill, however, no RCRA metals were present above cleanup limits. The fill in hole 12-2 was encountered from 5 to 8 feet. The remainder of the burned fill was present on the ground surface and varied between 1 and 3 feet in thickness. Contaminated soil ranged from 0 to 2 feet below the burned fill. No contaminants were detected in the pits which held the tubes containing igniter mix at the northern end of the site. An isopach of contaminated material is presented on drawing 3. Arsenic, barium, and lead are the major contaminants in the fill with concentrations as high as 24 mg/kg As, 10,000 mg/kg Ba, and 4300 mg/kg Pb. Also found in a few of the sampled pits were cadmium and chromium with levels of 42 mg/kg Cd and 280 mg/kg Cr. Contamination of the underlying soil was minor. Highest levels were found to be 20 mg/kg As, 400 mg/kg Ba, and 240 mg/kg Pb. Site 12 was also tested for pH. Results indicate that the fill and soil is slightly basic with pH ranging from 8.21 to 9.15. Approximately 11,200 cubic yards of fill and contaminated material are present at Site 12. See Section IV for expanded closure plan quantities.

(2) Fill and Underlying Soil (EP Toxicity Tests). EP toxicity tests were performed on samples just inside the physical boundary of contaminated materials based on total ion testing. In those cases where EP toxicity results exceeded the cleanup limit just inside the boundary, an additional sample just outside the boundary was tested. In all cases, total ion content was the controlling factor in setting the physical boundary of contaminated material. Additional EP tests were performed on the most highly contaminated samples of fill and soil from different parts of the site in order to judge the degree of contamination. All results are presented in table 3-2.

TABLE 3-2
RESULTS OF EP TOXICITY ANALYSIS
(mg/l)

Hole	Depth [1]	Ag	As	Ba	Cd	Cr	Hg	Pb	Se
3	0.0-1.0	<0.01	0.026	2.6	0.007	<0.01	<0.0001	0.09	<0.0004
	2.0-3.0	<0.01	0.001	1.5	<0.002	<0.01	<0.0001	0.05	<0.0004
5	0.0-0.9	<0.01	<0.001	93.0 [2]	0.015	0.02	<0.0001	0.36	<0.0004
	0.9-2.0	<0.01	0.002	0.55	0.005	<0.01	0.0008	0.04	0.0005
8	0.0-1.0	<0.01	0.003	5.7	0.098	0.02	<0.0001	0.71 [2]	0.0040
	1.0-2.0	<0.01	0.001	<0.5	0.005	<0.01	<0.0001	0.03	<0.0004
9	0.0-1.0	<0.01	0.006	2.7	0.017	<0.01	<0.0001	0.47	0.0030
10	0.0-1.0	<0.01	0.014	6.5	0.017	<0.01	<0.0001	0.12	0.0040
11	0.0-1.0	<0.01	0.010	0.63	0.005	0.02	0.0008	0.07	<0.0004
	2.0-3.0	<0.01	0.002	0.54	0.005	<0.01	0.0001	0.06	<0.0004
13	0.0-0.4	<0.01	<0.001	4.7	0.010	<0.01	<0.0001	0.09	<0.0004
16	0.0-1.0	<0.01	<0.001	3.1	0.007	0.03	<0.0001	0.15	<0.0004
19	0.0-3.5	<0.01	0.013	<0.5	0.033	0.01	<0.0001	0.07	<0.0004
22	0.0-2.0	<0.01	0.001	<0.5	0.005	<0.01	<0.0001	0.03	<0.0004
34	1.0-2.0	<0.01	0.008	<0.5	0.005	0.01	<0.0001	0.04	<0.0004
35	0.0-2.0	<0.01	0.064	<0.5	0.005	0.01	<0.0001	0.03	<0.0004
37	0.0-1.0	<0.01	0.054	<0.5	0.005	<0.01	<0.0001	0.04	<0.0004
49	0.0-1.0	<0.01	0.037	<0.5	0.005	<0.01	0.0004	0.04	<0.0004
RCRA limit		5.0	5.0	100.0	1.0	5.0	0.2	5.0	1.0

(1) See the boring column in Appendix III (Boring-Contaminant Plots) for location of sample tested for EP toxicity.

(2) Indicates that this test exceeds the ADPC&E cleanup limit for EP toxicity (10% of the RCRA limit).

f. Groundwater Contamination. Groundwater encountered at Site 12 belongs to the Jackson/Quaternary aquifer. This aquifer generally yields small amounts of poor quality water and is not used for any water supply purpose in the vicinity of the arsenal. Drinking water in the area is supplied from the Sparta Sand which is about 600 feet below the site and is separated from it by low permeability Jackson and upper Claiborne groups. Tests have been performed on groundwater samples from the four monitoring wells over a period of two years. Barium and chromium were the only heavy metal contaminants detected in the wells. Levels were very low with concentrations of 0.2 to 0.4 mg/l Ba and 0.01 to 0.03 mg/l Cr detected. Water quality standards are 1.0 mg/l Ba and 0.05 mg./l Cr. Based on the results of the analyses on the water samples from the groundwater monitoring wells, it is concluded that Site 12 is not contributing to groundwater contamination.

IV - CLOSURE PLAN

4-01. General. The closure plan for Site 12 consists of relocating the materials from this site to the Site 23A closure cell. As mentioned in the Site 23A Closure Plan, closure of Site 23A requires a considerable volume of off-site material to backfill the pond and provide above grade fill contours to promote site drainage. Consequently, compatibility tests were completed on samples from various sites, and it was determined that the Site 12 material is suitable for disposal at Site 23A. These test reports are given in Appendix IV. This type of off-site closure plan is environmentally feasible, since the waste material is not a hazardous waste. Consequently, its closure is not governed by RCRA regulations. Drawing 4 illustrates the regraded site, upon removal of the waste material. The following procedure would be followed during this closure process:

a. Site Clearing and Materials Relocation. Most of the site is wooded, requiring approximately 3.3 acres of clearing and grubbing to gain access to the waste material. The debris present at this site consists primarily of rusted munitions, shell casings and empty 55 gallon drums. The volume of this debris would be reduced as much as practical by crushing prior to its mixture with excavated contaminated soil materials in order to allow required compaction as fill material in order to minimize excessive settlement in the Site 23A closure cell. Allowing for 10% overexcavation, approximately 13,000 cubic yards of contaminated material would require removal to Site 23A.

During the excavation process, the area would be monitored for the presence of Agent Mustard. Should any be found, it will be decontaminated on-site, tested, and the byproducts transported to Site 23A for use as fill material. The decontaminated byproducts of Agent Mustard have been tested and are compatible with other wastes to be disposed at Site 23A. No active Agent Mustard will be transported off-site.

b. Site Restoration. Upon removal of the waste material, the site would be restored by replacing the excavated material with layers of compacted random fill material, followed by a topsoil layer and revegetation. During the process of backfilling the area, the fill would be graded to promote site drainage, and to eliminate the pits which are currently visually evident. Old mounds resulting from the original pit excavations would also be graded, in order to minimize off-site fill requirements and to result in a uniformly graded site. The final site contours are illustrated on drawing 4, with a 6-inch topsoil layer and revegetation consisting of temporary and permanent grass seeding, fertilizing and mulching.

c. Erosion Control. Most of the site is sufficiently flat to have a minimal erosion potential. Consequently, the previously-discussed revegetation and site maintenance would be adequate in the flat areas. A portion of the northern segment of the site is on the Arkansas River bank. Disturbed areas on and in the immediate vicinity of the river bank would receive a layer of erosion control fabric. That portion of the site below the 25-year flood plain would also receive a layer of 12 inch minimum sized rip-rap.

d. Site Maintenance. The site would remain closed to burning or surface debris disposal indefinitely. The site would require maintenance for a period of approximately 2 years to prevent erosion until vegetative growth is firmly established. Periodic inspections would be conducted thereafter to insure against potential erosion and settlement problems with specific attention paid to the river bank area. Since the entire site is below the river's 100-year flood plain, regrowth of trees and brush would be encouraged. Groundwater monitoring will be discontinued after site closure since contaminated materials will no longer be present at this site.

V - ALTERNATIVE CLOSURE PLANS

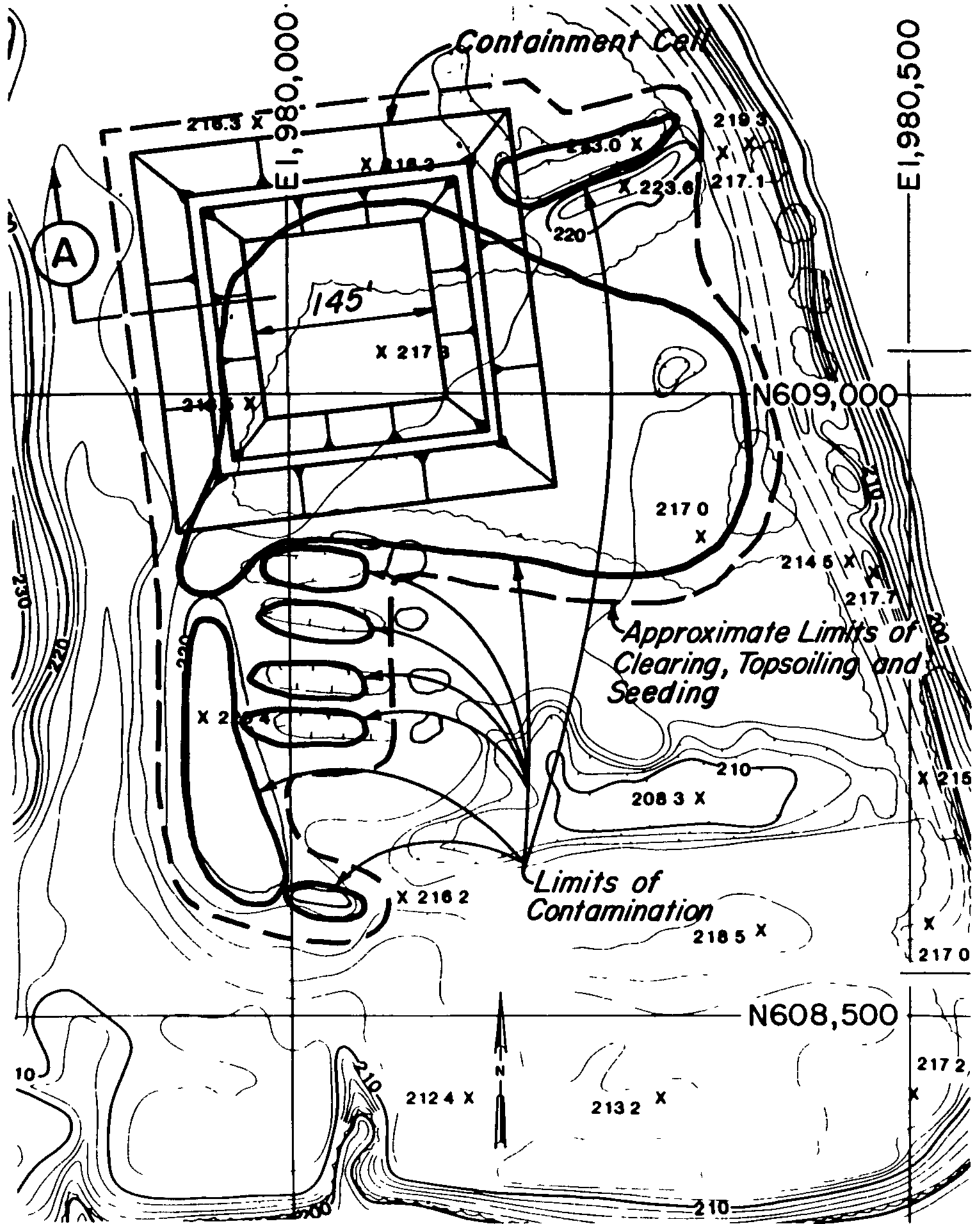
5-01. Alternative On-Site Closure Plan. This alternative closure plan would utilize the clay layer underlying a portion of the site to construct an on-site closure cell. A cutoff wall constructed of low-permeability material would be keyed into this clay layer, followed by a containment levee and cell cap, both also constructed of low-permeability material. Figure 5-1 illustrates this closure configuration. The closure cell would be located over a portion of the contaminated material, with the balance of the waste material to be excavated and placed within the limits of the closure cell.

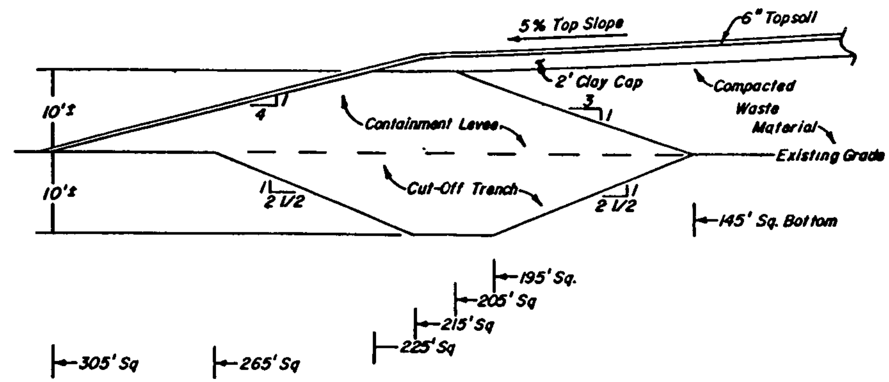
The completed cell would be topsoiled and revegetated, with the balance of the site to be filled, graded, and revegetated in a manner similar to that discussed in Section IV for the proposed closure plan. This alternative plan is feasible because the waste material is non-hazardous, and can therefore be consolidated on site, and because the erosion potential for the cell site is minimal, even though the average existing ground level is approximately 2 feet below the 100-year flood plain.

This alternative closure plan is not cost effective, as indicated in Section VI, primarily due to the quantity of low-permeability material required to construct the cut-off trench, the containment levee and the clay cap.

5-02. Alternative Off-Site Closure Plan. None of the other arsenal closure sites except Site 23A have sufficient excess space available for disposal of Site 12 wastes, consequently disposal at the hazardous waste landfill is the only alternative off-site closure plan which is technically feasible. This closure plan would be basically identical to the proposed closure plan with regard to remedial site work.

The hazardous waste landfill capacity required for this closure plan has been based on 15,500 cubic yards of material which allows for 15% overexcavation and a 20% volume increase to reflect the bulking which occurs during placement and recompaction. As itemized in Section VI, the costs associated with providing hazardous waste landfill capacity for the materials at this site eliminate this alternative from further consideration.



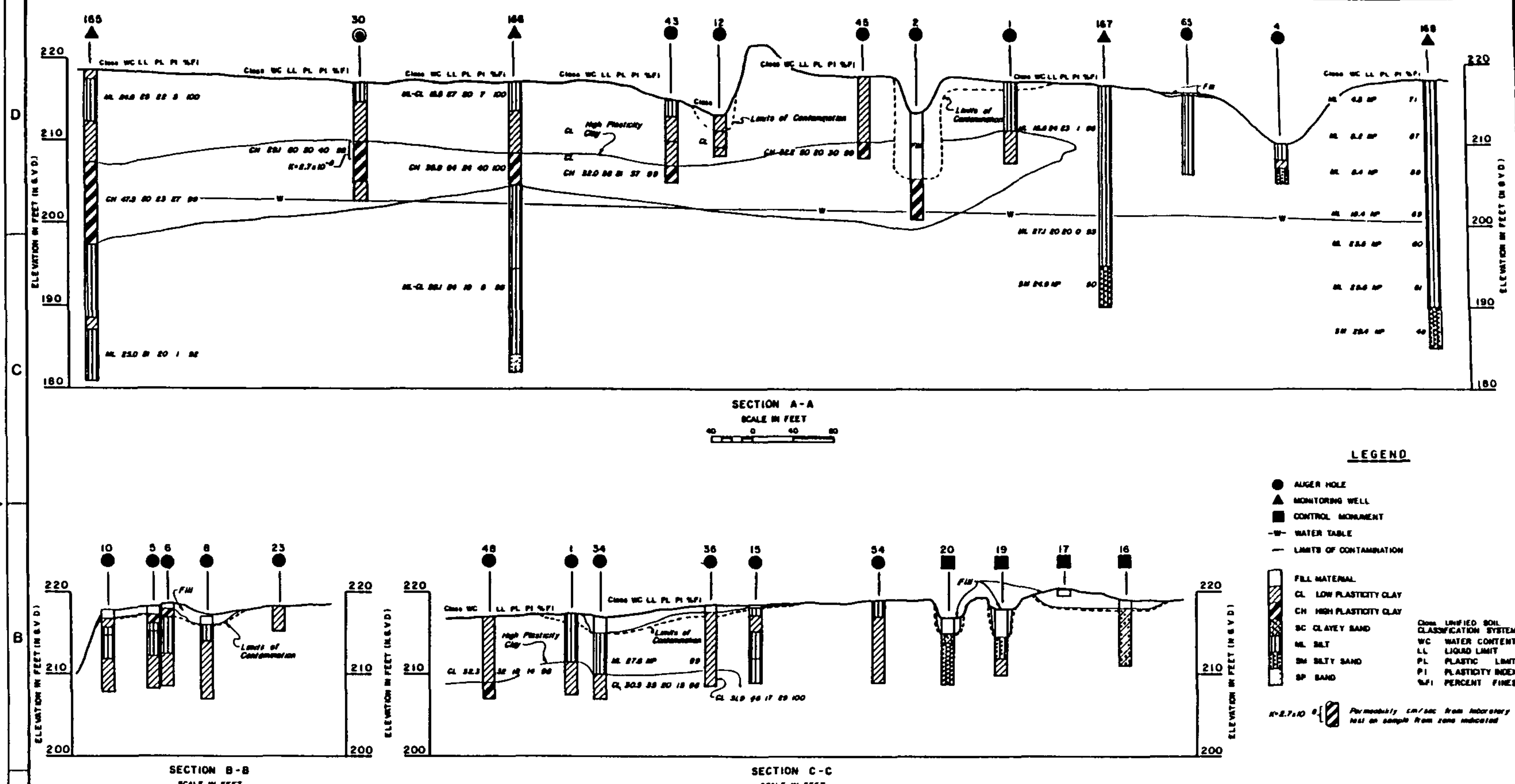


SECTION-A A

SCALE IN FEET

100 0 100 200

FIGURE 5-1
SITE 12
ALTERNATIVE ON-SITE
CLOSURE PLAN



Symbol	Descriptions	Date	Approved
	Revisions		

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
TULSA, OKLAHOMA

Designed by

Drawn by

Checked by

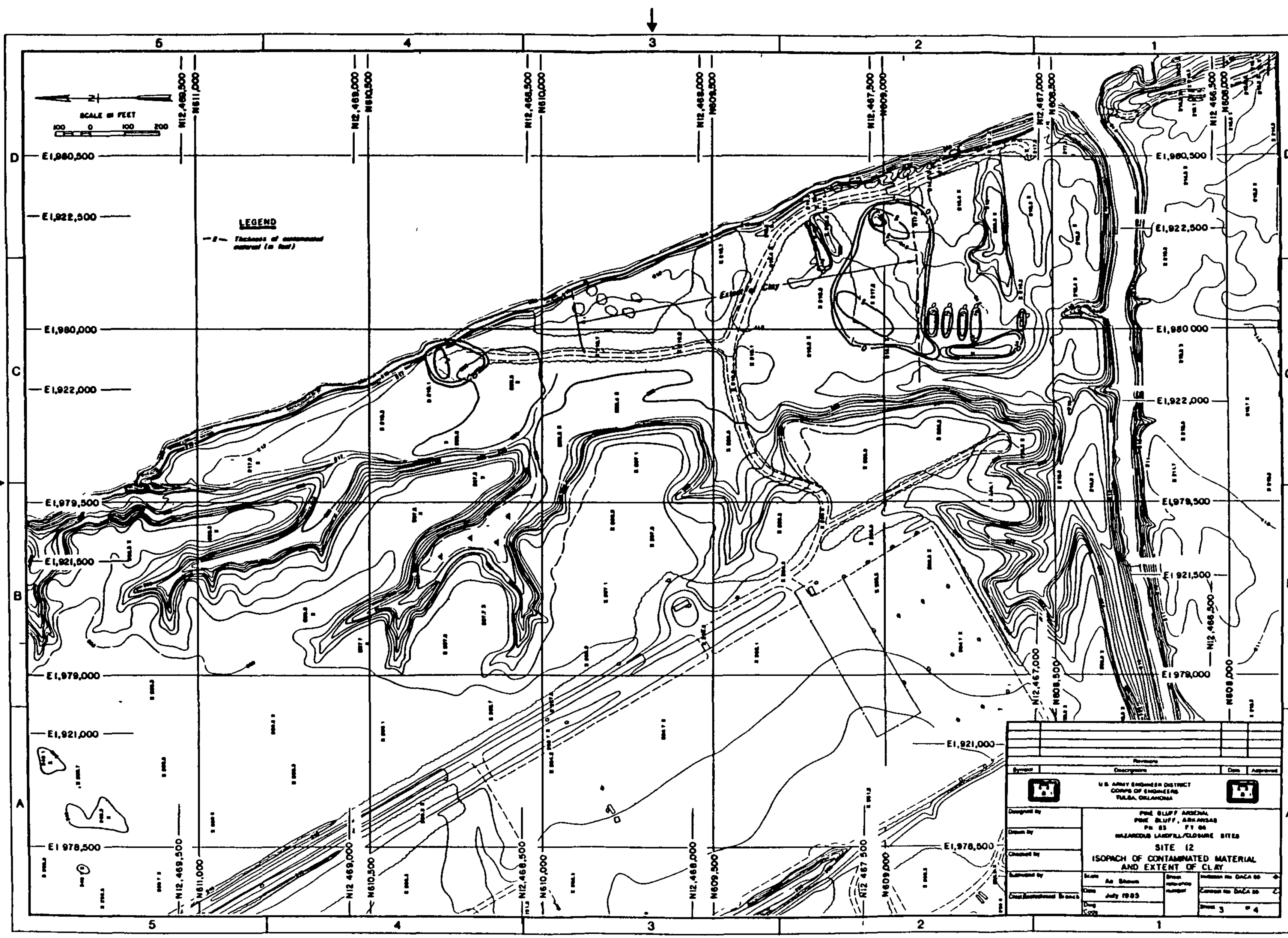
Submitted by

Chief Geotechnical Branch

PINE BLUFF ARSENAL
PINE BLUFF ARKANSAS
PN 83 FY 86
HAZARDOUS LANDFILL/CLOSURE SITES

SITE 12
GEOLOGIC SECTIONS A A B-B & C-C

Scale: As Shown
Date: July 1985
Dwg Code:
Sheet reference number:
Sheet 2 of 4



SCALE IN FEET
100 0 100 200
LEGEND
Thickness of contaminated material (in feet)
Extent of Clay
E1,980,500
E1,922,500
E1,980,000
E1,922,000
E1,979,500
E1,921,500
E1,979,000
E1,921,000
E1,978,500
N12,469,500
N611,000
N12,469,000
N610,500
N12,468,500
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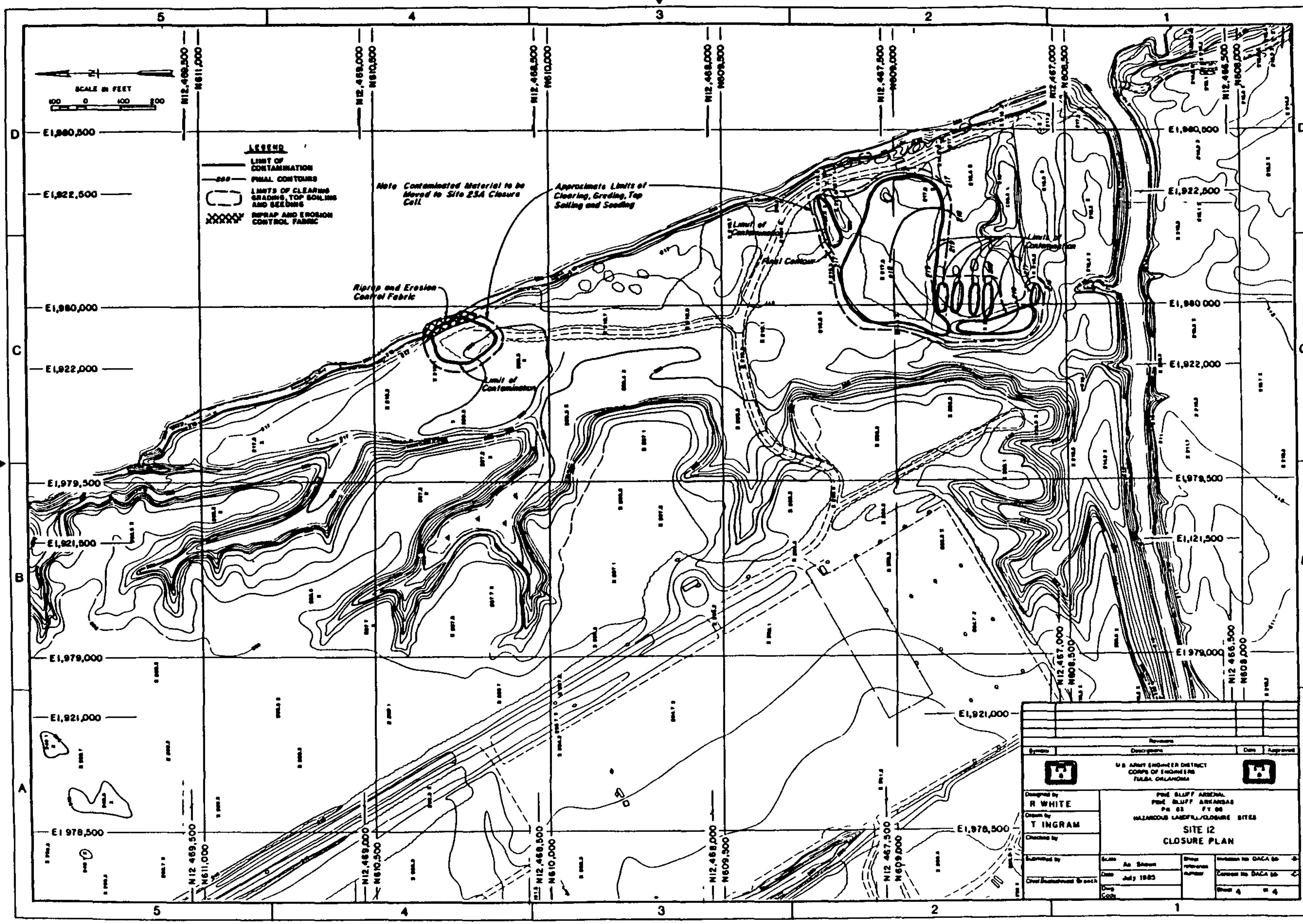
Revisions
Symbol
Descriptions
Date
Approved
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
TULSA, OKLAHOMA
PINE BLUFF ARSENAL
PINE BLUFF, ARKANSAS
HAZARDOUS LANDFILL/CLOSURE SITES
SITE 12
ISOPACH OF CONTAMINATED MATERIAL
AND EXTENT OF CLAY
Designed by
Drawn by
Checked by
Scale
As Shown
Date
July 1985
Sheet 3 of 4


SCALE IN FEET
100 0 100 200
LEGEND
LIMIT OF CONTAMINATION
FINAL CONTOURS
LIMITS OF CLEARING GRADING, TOP SOILING AND SEEDING
RIPRAP AND EROSION CONTROL FABRIC
Note Contaminated Material to be Moved to Site 23A Closure Cell
Approximate Limits of Clearing, Grading, Top Soiling and Seeding
Riprap and Erosion Control Fabric
Limit of Contamination
Final Contour
E1,980,500
E1,922,500
E1,980,000
E1,922,000
E1,979,500
E1,921,500
E1,979,000
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N12,468,500
N610,000
N12,468,000
N609,500
N12,467,500
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N608,500
N12,466,500
N608,000
Revisions
Symbol
Descriptions
Date
Approved
U S ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
TULSA, OKLAHOMA
Designed by
R WHITE
Drawn by
T INGRAM
Checked by
Submitted by
PINE BLUFF ARSENAL
PINE BLUFF ARKANSAS
HAZARDOUS LANDFILL/CLOSURE SITES
SITE 12
CLOSURE PLAN
Scale
As Shown
Date
July 1985
Sheet 4 of 4

PRE-SCORE

REFERENCE 14

STATE OF ARKANSAS
DEPARTMENT OF POLLUTION CONTROL AND ECOLOGY

* * * * * *

Regulation No. 2, As Amended
REGULATION ESTABLISHING WATER QUALITY STANDARDS FOR SURFACE WATERS OF THE STATE OF ARKANSAS

January, 1988

Designated Uses
Delta Ecoregion
(Plates D-1, D-2, D-3, D-4)

<u>Extraordinary Resource Waters</u>
- Second Creek (D-4)
- Cache River above Cache Bayou - adjacent to natural areas (D-3)
- Arkansas River below Dam #2 (D-5)
- Strawberry River (D-1)
- Two Prairie Bayou adjacent to natural areas (D-3)

<u>Natural and Scenic Waterways</u>
- None

<u>Ecologically Sensitive Waterbodies</u>
- Lower St. Francis River and lower 10 miles of Straight Slough - location of fat pocketbook mussel (D-2, D-4)
- Right Hand Chute at confluence with St. Francis River - location of fat pocketbook mussel (D-2)
- Departee Creek - location of flat floater mussel (D-1)
- Black River at mouth of Spring River - location of pink mucket mussel (D-1)

<u>Primary Contact Recreation</u> - all streams with watersheds of greater than 10 mi^2 and all lakes/reservoirs

<u>Secondary Contact Recreation</u> - all waters

<u>Domestic, Industrial and Agricultural Water Supply</u> - all waters

<u>Fisheries</u>
- Trout - none
- Lakes and Reservoirs - all
- Streams
  - Seasonal Delta fishery - all streams with watersheds of less than 10 mi^2 except as otherwise provided in Section 6(E)
  - Perennial Delta fishery - all streams with watersheds 10 mi^2 or larger and those waters where discharges equal or exceed 1 CFS

<u>Use Variation Supported by UAA</u>
- Unnamed ditch to Little Lagrue Bayou - perennial Delta fishery (D-3, #1)
- Little Lake Bayou - seasonal Delta fishery; no primary contact (D-5, #2)

PRE-SCORE

REFERENCE 15

STATE	CITY NAME	COMMUNITY	FIPSCODE	LATITUDE	LONGITUDE
AR	PINE BLUFF	OAK PARK	05069	34.2900	92.0933

Press RETURN key to continue ...

CENSUS DATA

Pine Bluff Arsenal
LATITUDE 34:20:22 LONGITUDE 92: 3:54 90BK POPULATION

KM	0.00-.400	.400-.810	.810-1.60	1.60-3.20	3.20-4.80	4.80-6.40	SECTOR TOTALS
S 1	0	0	0	0	545	543	1088
RING TOTALS	0	0	0	0	545	543	1088

Press RETURN key to continue ...
Esc for ATtention, Home to SWitch ¤ Capture Off ¤ On: 00:06:36

Accessed
6/4/93
Kenyon

PRE-SCORE

REFERENCE 16

RCRA FACILITY ASSESSMENT EVALUATION

PRELIMINARY REVIEW, VISUAL SITE INSPECTION AND SAMPLING VISIT

Region VI, Technical Compliance Section

LITY'S NAME(S): U.S. Pine Bluff Arsenal

ID NUMBER: ARD213820707

ESS: Roemer Road, Pine Bluff, Arkansas

TION: U.S. Highway 65 and Roemer Road Pine Bluff, AR

OF INSPECTION: May 18-23, 1987

OF SAMPLING VISIT: August 24-25, 1987 SV CONDUCTED BY: A.T. Kearney/Centaur

DESCRIPTION: US Army facility manufacturing and assembling incendiary devices.

RED BY: A.T. Kearney-Centaur DATE PREPARED: July 16, 1987

EWED BY: Bobby Williams DATE REVIEWED: August 1987 / 12-2-87

CIPATED DRAFT PERMIT DATE: 3rd Qtr., 1987

LITY STATUS: Active

ON-GOING STATE/FED 264, 265, or 270 CORRECTIVE ACTION OR CERCLA ACTION: Yes

historical sites identified in 1984 for closure by ADPC&E.

FACILITY HAVE A CERCLA FILE? YES X NO ____

was the CERCLA PA/SI performed at this facility: March 2, 1982

FACILITY HAVE UIC WELL? YES ____ NO X

PE: ____

OF DRINKING WATER SUPPLY WITHIN A 3-MILE RADIUS:

low wells for human consumption.

T POPULATION WITHIN A 3-MILE RADIUS: Approximately 500 persons.

ENDATIONS: X R.F.I. ____ I.M. ____ No Further Action under RFA

(Indicate only one unless I.M. is marked)

X 3004(u) ____ 3007

Possible Enforcement Action: ____ 3008(a) ____ 3008(h)

Rev. 10/6/87

5.10 SWMU #10 - Mustard Burn Pits (Site 12) (Photo A.71)

5.10.1 Information Summary

Unit Description: The Mustard Burn Pits are east of SWMU # 7 - Bombing Mat (Section 5.7) on Doolittle Road. The unit was primarily used as a burn and disposal area for mustard munitions. Scattered across the surface area are trenches that are a result of the disposal operations. Four parallel trenches on the southern end of the unit contain rusted munitions and 55-gallon drums. A larger pile of debris exists west of the these trenches where shell casings were stacked and burned with Thermite. A smaller pile is present south of the trenches. A large burning area located in the central portion of the unit covers approximately one acre. Ash and debris are scattered over the burned ground and a heavy cover of grass now masks much of the area (Photo A.71). Pits on the northern end of the unit contain the remains of tubes which held igniter mix for the munitions. A smaller burn area in the northern portion of the unit covers about 10,000 square feet. The unit is adjacent to the Arkansas River and is relatively flat at an approximate elevation of 218 feet above MSL, just below the 100-year flood elevation of 220.3 feet above MSL. Grass, heavy underbrush, and trees now cover the site. This unit is not a RCRA-regulated unit. ADPC&E has approved a Closure Plan for this unit. (21, 23, 37)

Dates of Operation: This unit was active from 1942 to 1948. (21) It is an inactive unit.

Wastes Managed: Wastes managed at this unit include mustard munitions. (19)

Release Controls: There are no release controls associated with this unit.

History of Releases: Contaminants detected at the burn pits include arsenic, barium, cadmium, chromium, lead and mustard by-products (sulfur). This information was collected from 105 borings and four monitoring wells. The materials found to be contaminated are fill, surface and shallow soils and ground water. Fill is considered to be burn residue and is present at several points at the site. Contamination of soils reached three feet in depth and 11,200 cubic yards in volume. The highest concentration of contaminants found in the soils are as follows: arsenic, 24 mg/kg; barium, 10,000 mg/kg; cadmium, 42 mg/kg; chromium, 280 mg/kg; lead, 4,300 mg/kg; sulfur, 12,000 mg/kg. Ground water at the unit occurs at approximately 17 feet and was sampled from four wells ranging from 25 to 38 feet in depth. Barium (0.4 ppm) and chromium (0.03 ppm) were the only heavy metals detected. (21)

5.10.2 Release Potential

- Soil/Ground Water: The soil at the unit is contaminated and the ground water exhibited the presence of metals in concentration below drinking water standards. (21)

- Surface Water: There is a high potential for surface water contamination. The soil is already contaminated and the unit is on the bank of the Arkansas River.

- Air: There is a low potential for an air release due to the length of time the wastes have been here.

- Subsurface Gas: There is a low potential for subsurface gas generation due to the composition of the wastes.

5.11 SWMU # 11 - Abandoned Burn Pit (Site 13A) (Photos A.73-A.74)

5.11.1 Information Summary

Unit Description: The Abandoned Burn Pit is located on McCoy Road about one mile west of SWMU #7 - Bombing Mat (Section 5.7). It was used as a burn area for pyrotechnic materials, particularly CN, a tear agent. The unit is approximately 12 acres and is relatively flat. It is about 245 feet above MSL, and ranges from partly barren to partly grassed and wooded. A small natural drainage area with a small pond exists near the center of the unit. Some regrading and covering has apparently taken place. Burn residue is visible on the surface area. This is not a RCRA-regulated unit. (5)

Date of Operation: This unit was active from World War II through the late 1960s. (5)

Wastes Managed: This unit burned pyrotechnic materials, particularly CN, a tear agent.

Release Controls: There are no release controls associated with this unit.

History of Releases: A total of 86 borings was completed at this unit and ranged in depth from five to forty feet. Sixty borings were drilled to about 10 feet. Soils, burn residue and the perched water table (one-two feet in depth) were analyzed for heavy metals. Lead contamination in surface soils ranged from 10 mg/kg to 96 mg/kg. Sampling of the perched water table (one-two feet) indicated arsenic and lead contamination at 0.09 ppm and 0.06 ppm, respectively. (5)

5.11.2 Release Potential

- Soil/Ground-Water: The soil is contaminated with arsenic and lead. There is a low potential for ground-water contamination, since the water table is about 40 feet below ground surface and the presence of clays and fine grained sands above the water table.

- Surface Water: There is a high potential for surface water contamination. This unit is drained by a small intermittent stream which in turn drains into Tulley Lake.

- Air: The potential for an air release is low since any volatilization of constituents would have already occurred.

- Subsurface Gas: There is a low potential for subsurface gas generation due to the composition of the wastes.

US Army Corps
of Engineers
Little Rock District
Tulsa District

PINE BLUFF ARSENAL
PINE BLUFF, ARKANSAS

RCRA FACIILITY INVESTIGATION WORKPLAN
GROUP II SWMU's

APRIL 1991

RCRA FACILITY INVESTIGATION WORKPLAN REPORT
PINE BLUFF ARSENAL
GROUP II SOLID WASTE MANAGEMENT UNITS
EXECUTIVE SUMMARY

This report is submitted in response to Joint Permit 13-H which requires that Pine Bluff Arsenal submit a Workplan Report on the 20 Group II Solid Waste Management Units (SWMUs) by 1 May 1991. This report presents the investigative history of the 20 Group II SWMUs from waste generation to the design of site remediation. Due to the large number of SWMUs involved and the need to present the information in a consistent and readily understandable format, the report consists of a main volume with appendixes. The main volume contains general information and is designed to provide the reviewer with an overview of the investigations and the remediation design.

General information is presented in the front of the main report and specific information regarding individual SWMUs is presented in the latter portion of the same volume. The SWMUs are discussed in separate sections of the report divided by index tabs. Each SWMU section concisely describes the unit, the waste constituents, the geotechnical and groundwater investigations, and the design of remedial actions. Maps and drawings are provided for each SWMU showing unit location, monitoring well and soil sample locations, pertinent geologic information and site closure plans. The groundwater and soil sample data, used as the design basis, are summarized and presented in tables.

The site closures at these 20 SWMUs were designed and constructed in compliance with two previous legal documents: a consent agreement between PBA and ADPCE dated May 4, 1984; and Joint Hazardous Waste Management Permit Number 9-H, which was issued by the EPA and the ADPCE to PBA on 3 July 1986. The design and construction were completed before preparation of a RCRA Facility Investigation Workplan became a requirement under Permit 13-H. This Workplan Report documents the investigations leading up to the design and construction. The closure design reports are provided as supplementary information along with information documenting the investigation methodology.

Remedial actions for the 20 Group II SWMUs were included in the Fiscal Year 1986 MCA (Military Construction - Army) Project that included closure of 21 historic waste sites and provided run-on/run-off control at two additional sites. The closure methods included removal of contaminated material and/or in-place isolation utilizing an impervious cap (at Site 16A) or a combination of a slurry wall and an impervious flexible membrane lined cover. The overall scheme is summarized in Figure 3 and each individual Group II SWMU is discussed later in this volume and detailed in the respective appendix. Remediation of each site has been completed and will be documented in the follow-on RFI Report.

No additional studies are planned, since remediation has been completed. The groundwater monitoring will continue as required by Permit 13-H and the individual site closure plans.

RCRA FACILITY INVESTIGATION WORKPLAN REPORT
PINE BLUFF ARSENAL
GROUP II SOLID WASTE MANAGEMENT UNITS

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VOLUME 1

The remaining subsections are separated by index tabs and the page numbers indicate the site number and the order of the page in the subsection.

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b.	Description of methods and procedures to be used to assess the precision, accuracy and completeness of the measurement data;	Appendixes H and I
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i.	Selecting appropriate sample containers;	D-27

	j.	Sample preservation; and	B-15, D-48, F-3, G-8, I-32, I-37
	k.	Chain-of-custody.	A-6, D-42, I-59, I-70
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	b.	Sample storage procedures and holding times;	B-15, D-48
	c.	Sample preparation methods;	A-7, B-12, B-16
	d.	Analytical procedures;	Appendixes A, B, and C; F-5, G-10, I-33, I-39
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	f.	Data reduction, validation and reporting; and	A-13, G-16, I-35
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2.		Tabular Displays	Refer to Main Report and SWMU Discussions
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This list is based on pages 65 through 68 of Pine Bluff Arsenal RCRA Permit No. 13-H.

11.7: SITE 12 - SWMU NUMBER 10
Mustard Burn Pits

LIST OF PERTINENT SITE MAPS AND PLANS:
- UNIT LOCATION MAP: Figure 12-1
- PLAN OF EXPLORATIONS: Figure 12-2
- GEOLOGIC SECTION: Figure 12-3
- ISOPACH OF CONTAMINATED MATERIAL: Figure 12-4
- MONITORING WELLS: Figure 12-5
- SITE CLOSURE PLAN: Figure 12-6

UNIT DESCRIPTION: Site 12, the Mustard Burn Pits, was originally a 25 acre wooded area containing several mounds and trenches and a one acre burn area in the center. The site was used from 1942 through 1948 for the burn and disposal of mustard munitions. The location of Site 12 is shown on Figure 12-1.

DESCRIPTION OF CONTAMINANTS: The site contained wastes from the disposal of mustard munitions. The contaminants included heavy metals. Figure 12-4 presents an isopach of the contaminated area. Neither surface waste nor subsurface materials classified as hazardous waste. Concentrations of contaminants in groundwater samples did not exceed water quality standards.

INVESTIGATIONS

SOIL SAMPLING: Fifty-six auger holes 5 to 15 feet deep and one denison hole 15 feet deep, were drilled in 1984 and 1985. Boring locations and a subsurface profile are shown on Figures 12-2 and 12-3. In addition eight test pits were dug in the trenches and munitions piles. Soil from the holes was described in the field and shipped to the Corps of Engineers Southwestern Division Laboratory in Dallas for classification and EP toxicity testing. Falling head permeability tests were performed on six undisturbed denison samples. Those holes which penetrated a clay layer were backfilled with grout. Soil sample results are summarized in Tables 12-1 and 12-2.

GROUNDWATER MONITORING: In 1982, one upgradient and 3 downgradient monitoring wells were installed with reporting on STORET. Locations of monitoring wells are shown on Figure 12-5. Groundwater monitoring data is presented in Tables 12-3 through 12-6.

REMEDIAL ACTION: The contaminated material (15,500 cubic yards) would be taken to Site 23A (SWMU Number 62), where fill material would be needed in order to complete the Site 23A closure. A site plan of the closure is shown on Figure 12-6. A detailed description of the recommended remedial actions is provided in the Mustard Burn Pits Closure Plan.

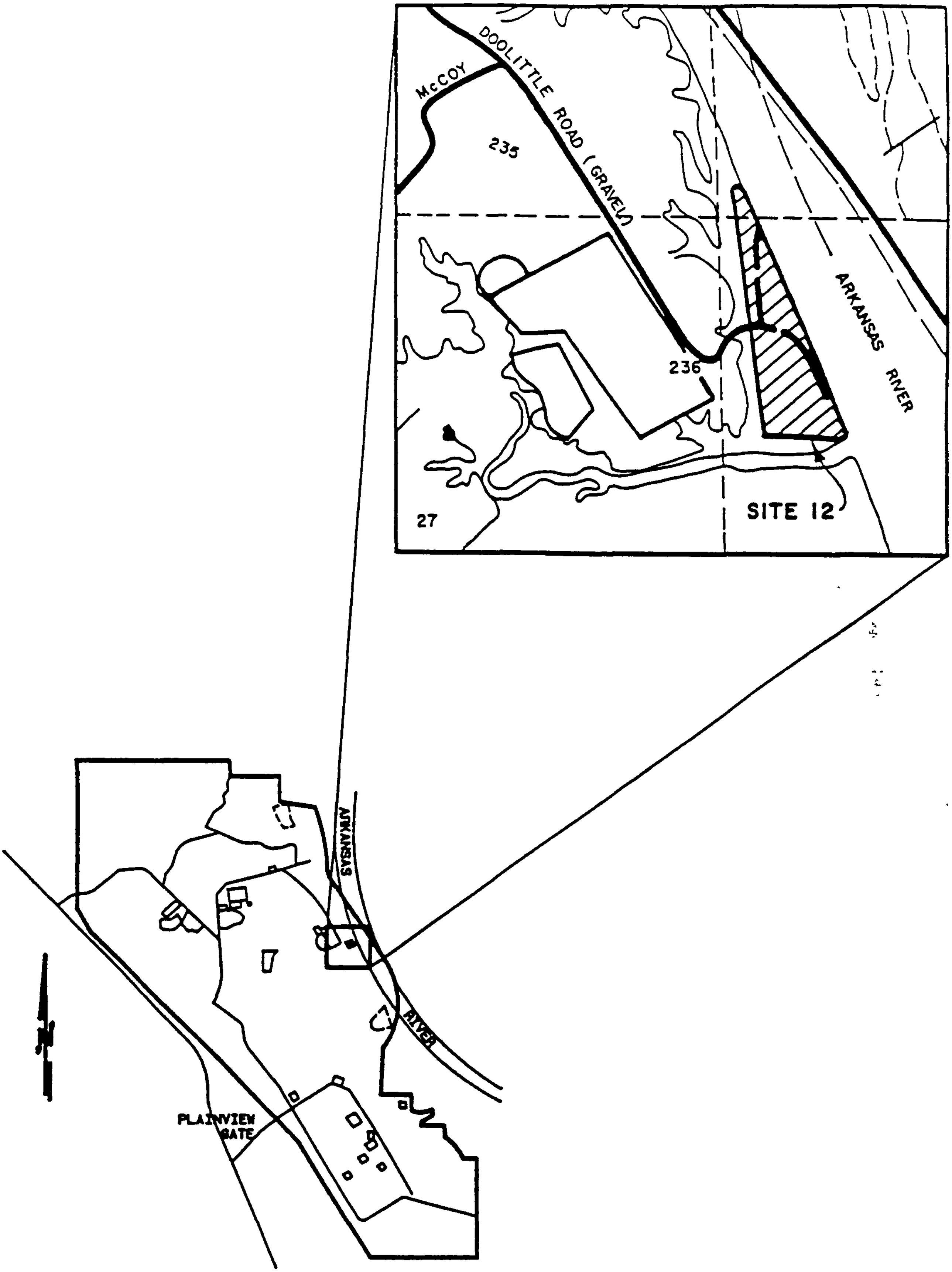


Figure 12-1 Site 12 Location Map

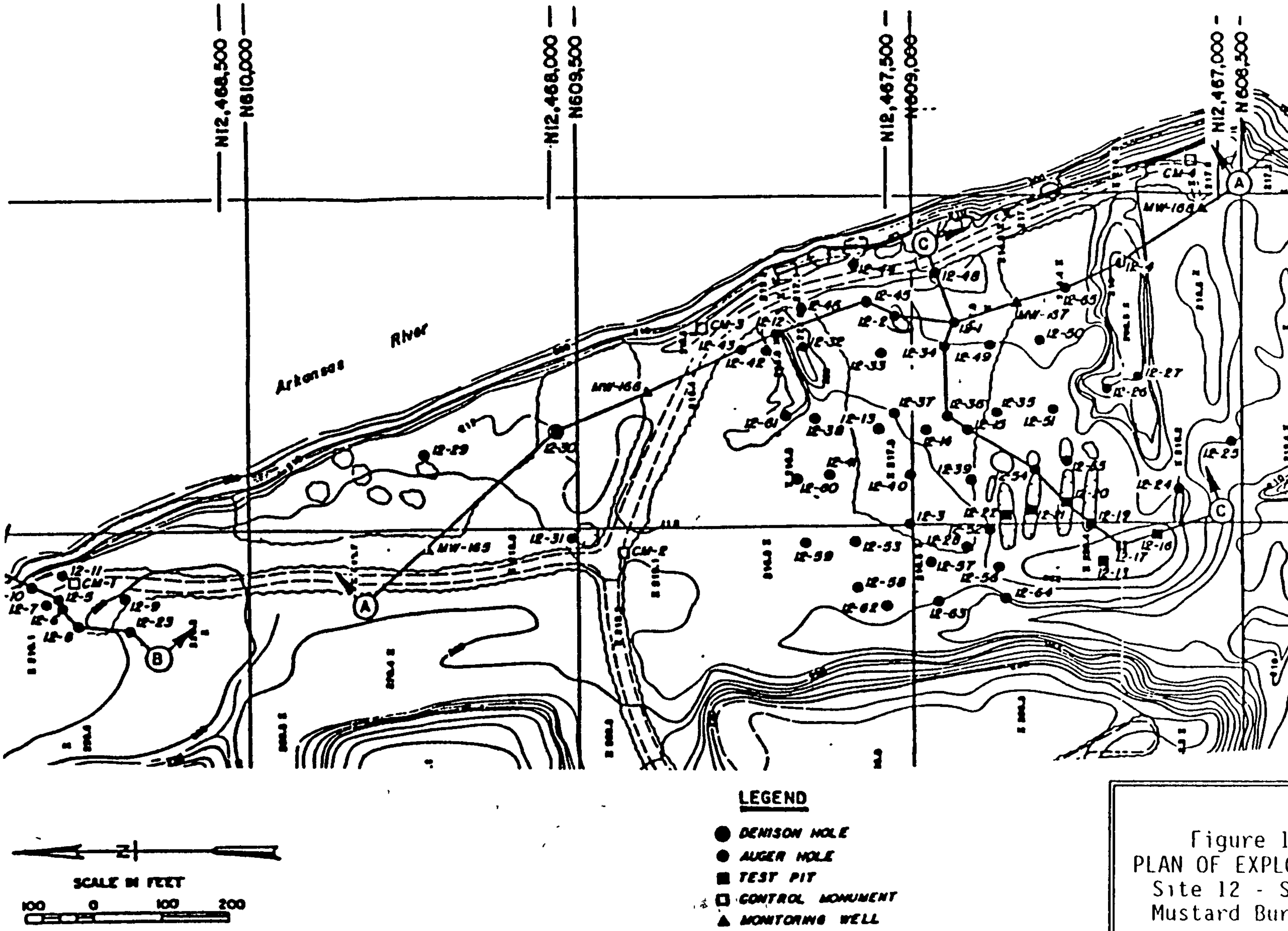
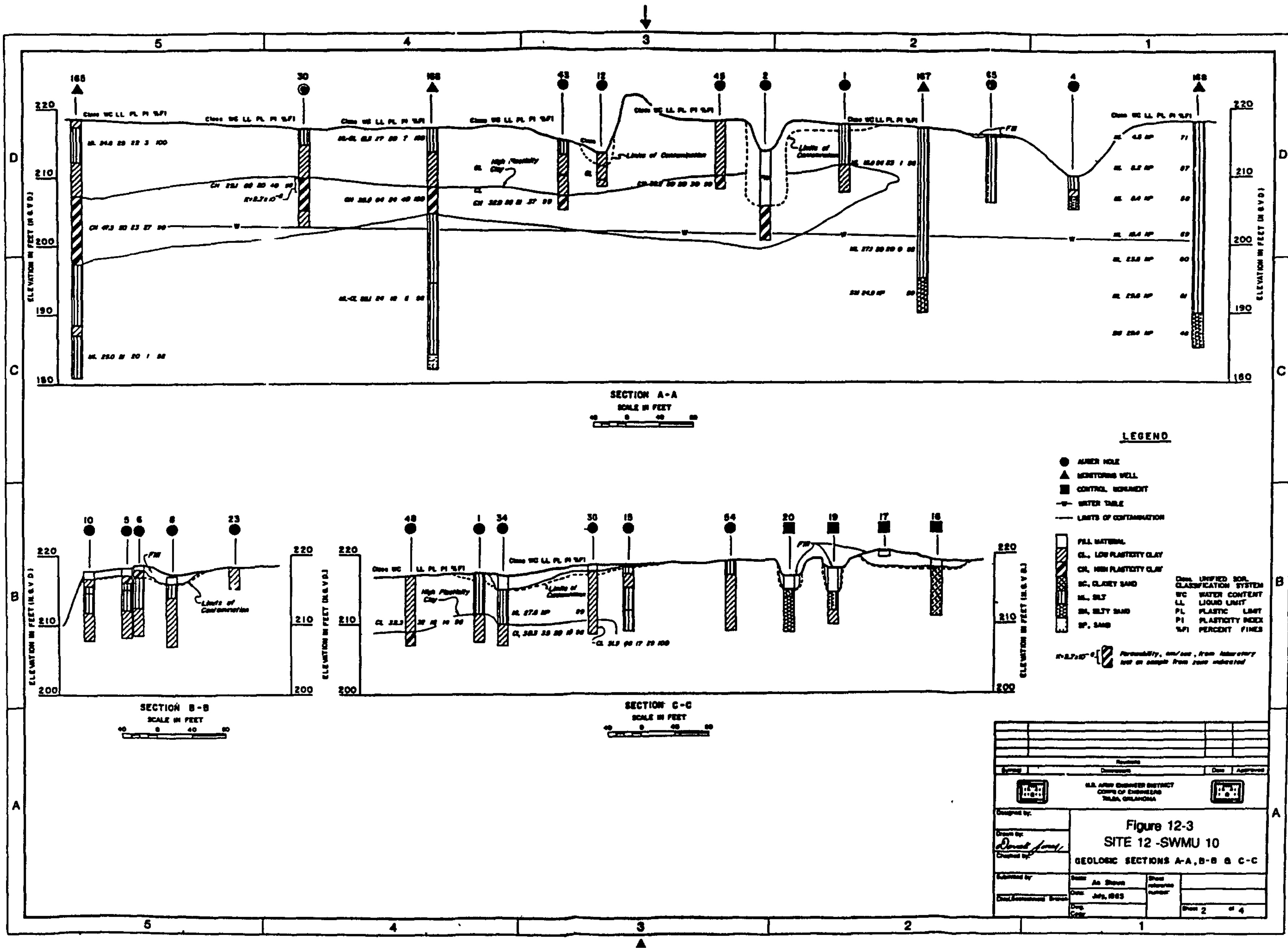


Figure 12-2
PLAN OF EXPLORATIONS
Site 12 - SWMU 10
Mustard Burn Pits



SECTION A-A
SCALE IN FEET
SECTION B-B
SCALE IN FEET
SECTION C-C
SCALE IN FEET
ELEVATION IN FEET (N.G.V.D.)
LEGEND
AUGER HOLE
MONITORING WELL
CONTROL MONUMENT
WATER TABLE
LIMITS OF CONTAMINATION
FILL MATERIAL
CL, LOW PLASTICITY CLAY
CH, HIGH PLASTICITY CLAY
SC, CLAYEY SAND
ML, SILT
SM, SILTY SAND
SP, SAND
Class UNIFIED SOIL CLASSIFICATION SYSTEM
WC WATER CONTENT
LL LIQUID LIMIT
PL PLASTIC LIMIT
PI PLASTICITY INDEX
%FI PERCENT FINES
Limits of Contamination
High Plasticity Clay
Fill
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
TULSA, OKLAHOMA
Figure 12-3
SITE 12 -SWMU 10
GEOLOGIC SECTIONS A-A, B-B & C-C
As Shown
July, 1993

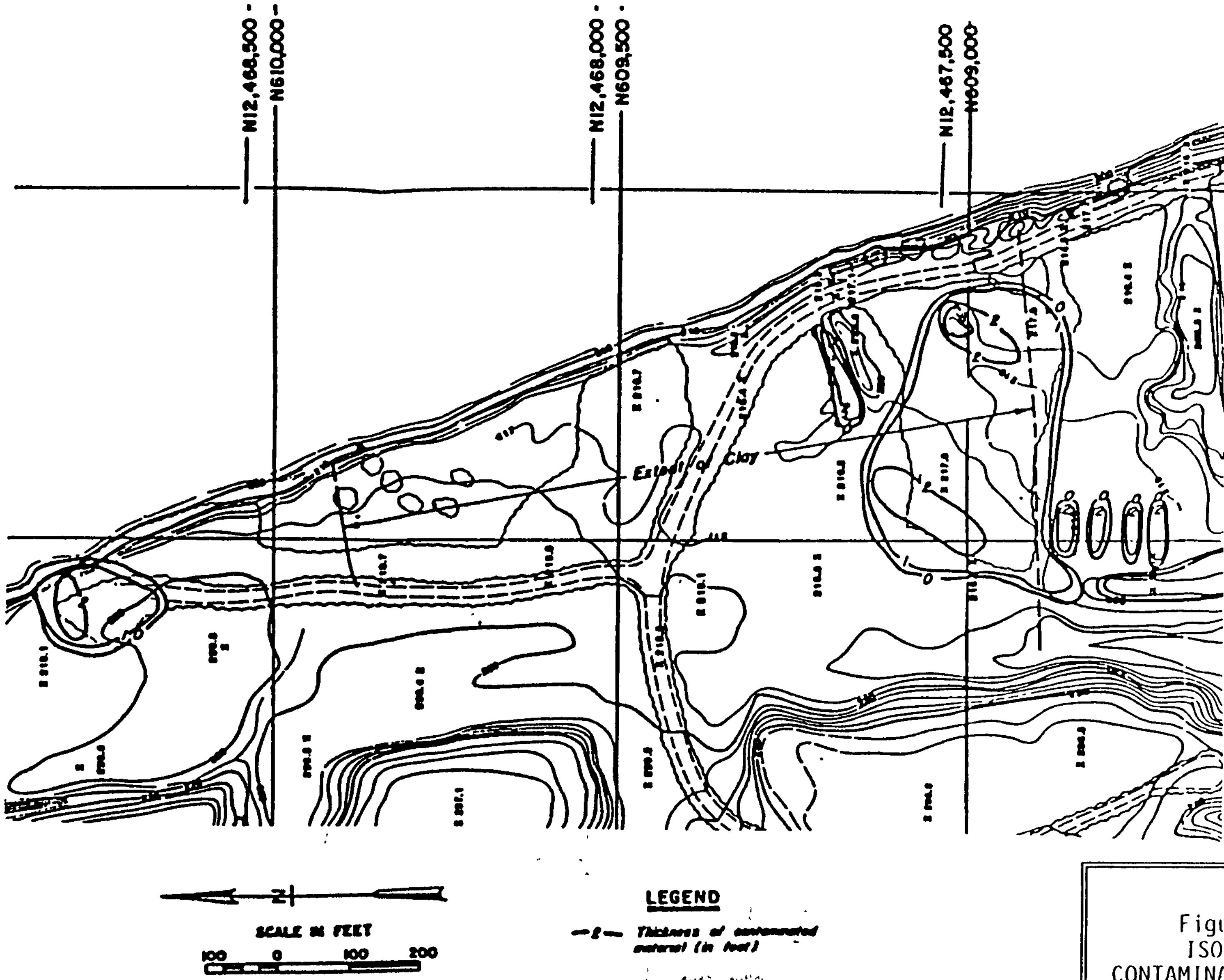
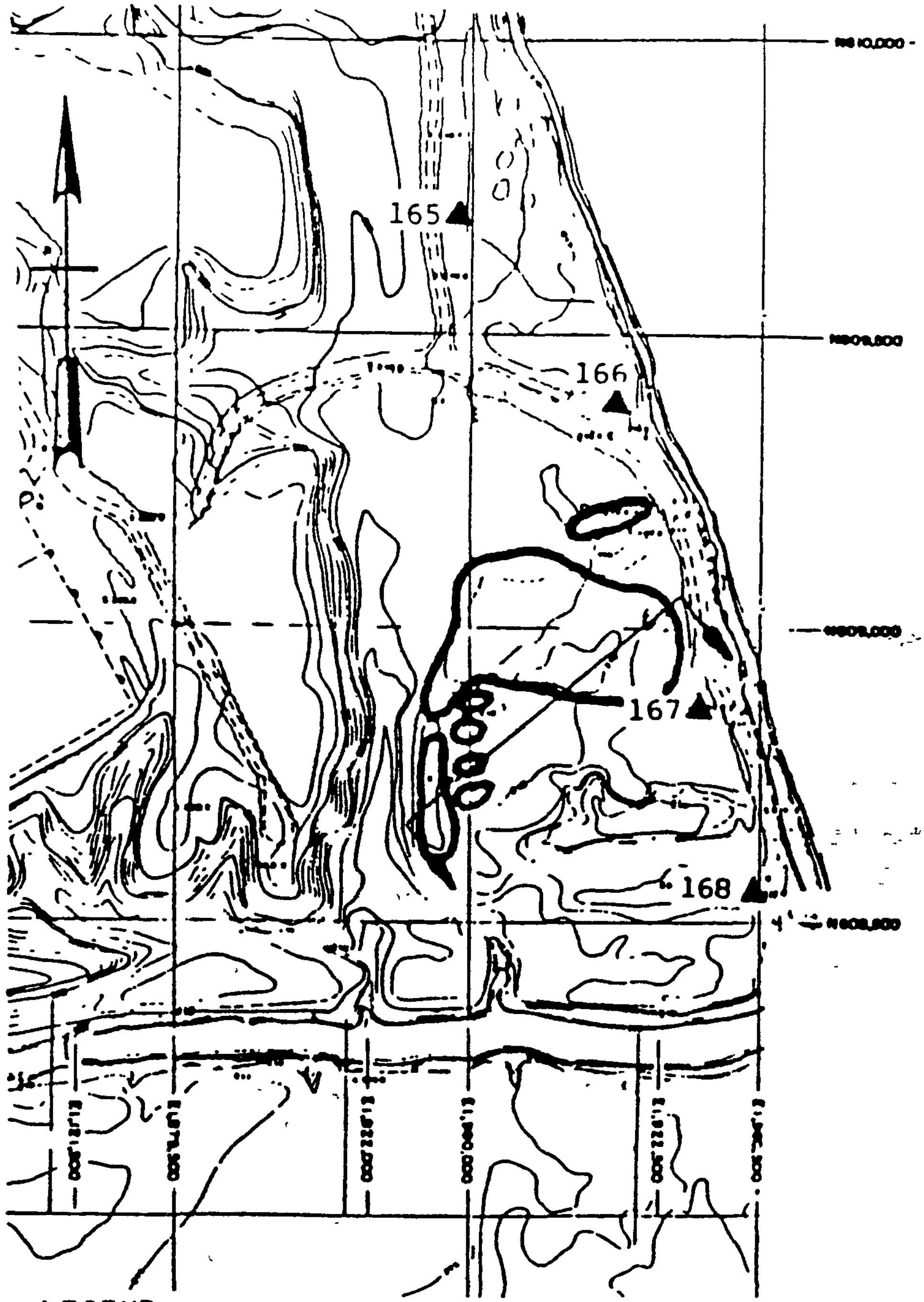


Figure 12-4
ISOPACH OF
CONTAMINATED MATERIAL
Site 12 - SWMU 10
Mustard Burn Pits



LEGEND

▲ EXISTING MONITORING WELL

LIMITS OF CONTAMINATION

GEOLOGIC SECTION

FIGURE 12-5
MONITORING WELLS
Site 12 - SWMU 10
Mustard Burn Pits

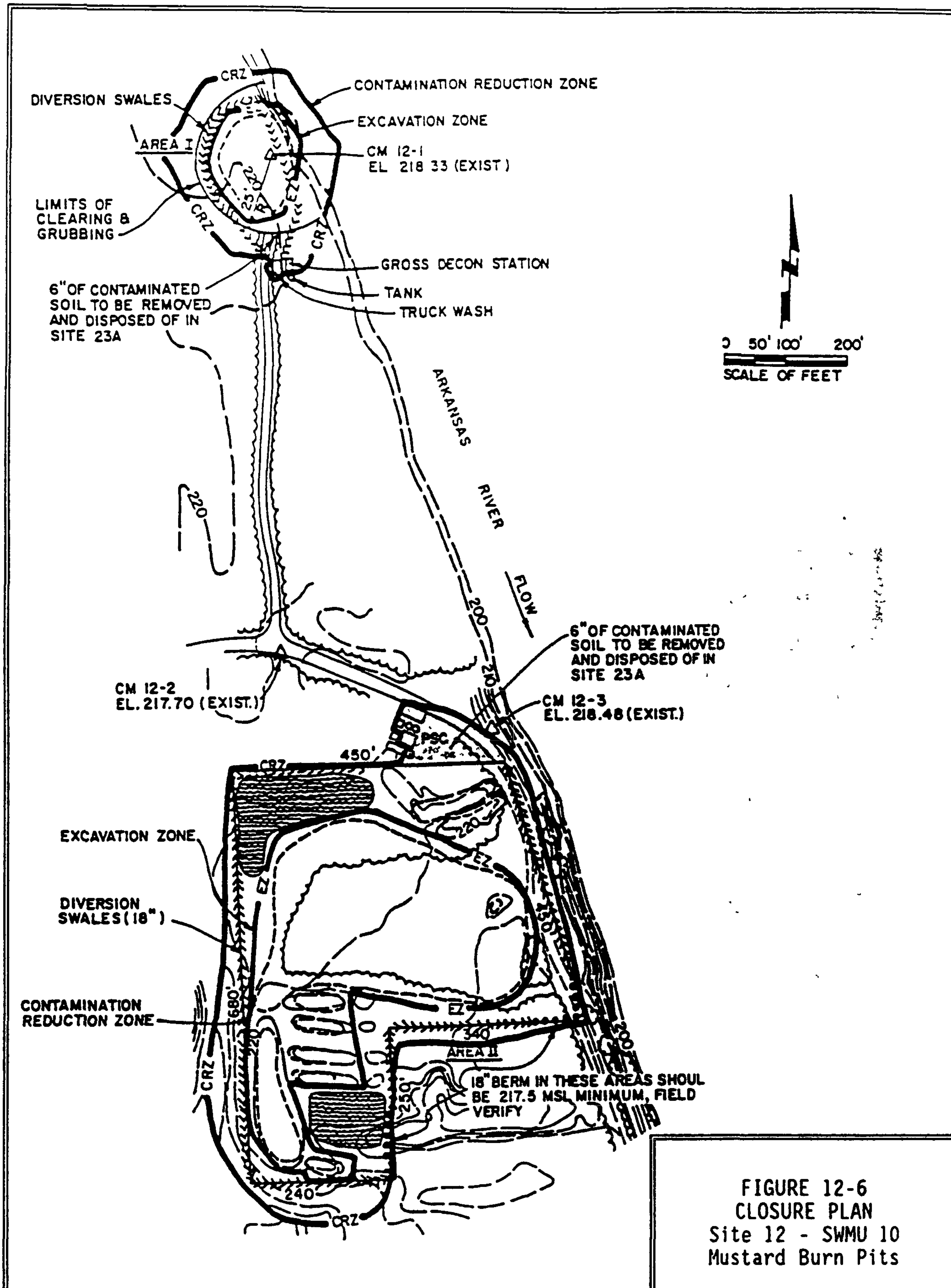


FIGURE 12-6
CLOSURE PLAN
Site 12 - SWMU 10
Mustard Burn Pits

TABLE 12-1
EP TOXICITY ANALYSIS (mg/l)
Mustard Burn Pits
Site 12 - SWMU 10

HOLE	DEPTH	Ag	As	Ba	Cd	Cr	Hg	Pb	Se
3	0.0-1.0	<0.01	0.026	2.6	0.007	<0.01	<0.0001	0.09	<0.0004
3	2.0-3.0	<0.01	0.001	1.5	<0.002	<0.01	<0.0001	0.05	<0.0004
5	0.0-0.9	<0.01	<0.001	93.0◊	0.015	0.02	<0.0001	0.36	<0.0004
5	0.9-2.0	<0.01	0.002	0.55	0.005	<0.01	0.0008	0.04	0.0005
8	0.0-1.0	<0.01	0.003	5.7	0.098	0.02	<0.0001	0.71◊	0.0040
8	1.0-2.0	<0.01	0.001	<0.5	0.005	<0.01	<0.0001	0.03	<0.0004
9	0.0-1.0	<0.01	0.006	2.7	0.017	<0.01	<0.0001	0.47	0.0030
10	0.0-1.0	<0.01	0.014	6.5	0.017	<0.01	<0.0001	0.12	0.0040
11	0.0-1.0	<0.01	0.010	0.63	0.005	0.02	0.0008	0.07	<0.0004
11	2.0-3.0	<0.01	0.002	0.54	0.005	<0.01	0.0001	0.06	<0.0004
13	0.0-0.4	<0.01	<0.001	4.7	0.010	<0.01	<0.0001	0.09	<0.0004
16	0.0-1.0	<0.01	<0.001	3.1	0.007	0.03	<0.0001	0.15	<0.0004
19	0.0-3.5	<0.01	0.013	<0.5	0.033	0.01	<0.0001	0.07	<0.0004
22	0.0-2.0	<0.01	0.001	<0.5	0.005	<0.01	<0.0001	0.03	<0.0004
34	1.0-2.0	<0.01	0.008	<0.5	0.005	0.01	<0.0001	0.04	<0.0004
35	0.0-2.0	<0.01	0.064	<0.5	0.005	0.01	<0.0001	0.03	<0.0004
37	0.0-1.0	<0.01	0.054	<0.5	0.005	<0.01	<0.0001	0.04	<0.0004
49	0.0-1.0	<0.01	0.037	<0.5	0.005	<0.01	0.0004	0.04	<0.0004
Cleanup Limit		0.5	0.5	10.0	0.1	0.5	0.02	0.5	0.1

◊Indicates that this test exceeds the ADPC&E cleanup limit for EP Toxicity (10% of the RCRA limit).

TABLE 12-2
SOIL CHEMISTRY AND CLEANUP LIMITS
Mustard Burning Pits
Selected Samples to Illustrate Contamination, mg/kg
SITE 12 - SWMU 10

HOLE	DEPTH	Silver	Arsenic	Barium	Cadmium	Chromium	Mercury	Lead	Selenium	Zinc
12-1	0.0-1.0	0.7	8.3	170	0.7	16	<0.1	200	<0.1	
12-1	1.0-2.0	<0.5	1.9	90	0.7	8.0	<0.1	39	<0.1	
12-1	2.0-3.0	<0.5	1.1	52	<0.5	5.1	<0.1	6.4	<0.1	
12-1	3.0-6.0	<0.5	1.2	61	<0.5	6.4	<0.1	12	<0.1	
12-1	6.0-9.0	<0.5	1.8	100	<0.5	10.0	<0.1	8.5	<0.1	
12-1	9.0-10.0	0.5	2.5	150	0.5	8.4	<0.1	11	<0.1	
12-5	0.0-0.9	7.9	5.8	10,000	4.8	280	<0.1	1,100	1.0	
12-5	0.9-2.0	0.7	6.1	310	0.9	11	<0.1	19	<0.1	210
12-5	2.0-3.0		4.2							35
12-13	0.0-0.4	0.6	<0.1	2,600	0.6	45	<0.1	5.6	<0.1	19
12-13	0.4-1.4	<0.5	3.9	94	0.3	11	<0.1	11	<0.1	37
Cleanup Limit		5.0	13.0	290.0	5.0	50.0	1.0	75.5	1.8	**

** Background level for zinc was determined since it is a common constituent of demilitarized ordnance wastes. Zinc is not a RCRA-listed contaminant, therefore, cleanup limits were not required by ADPC&E.

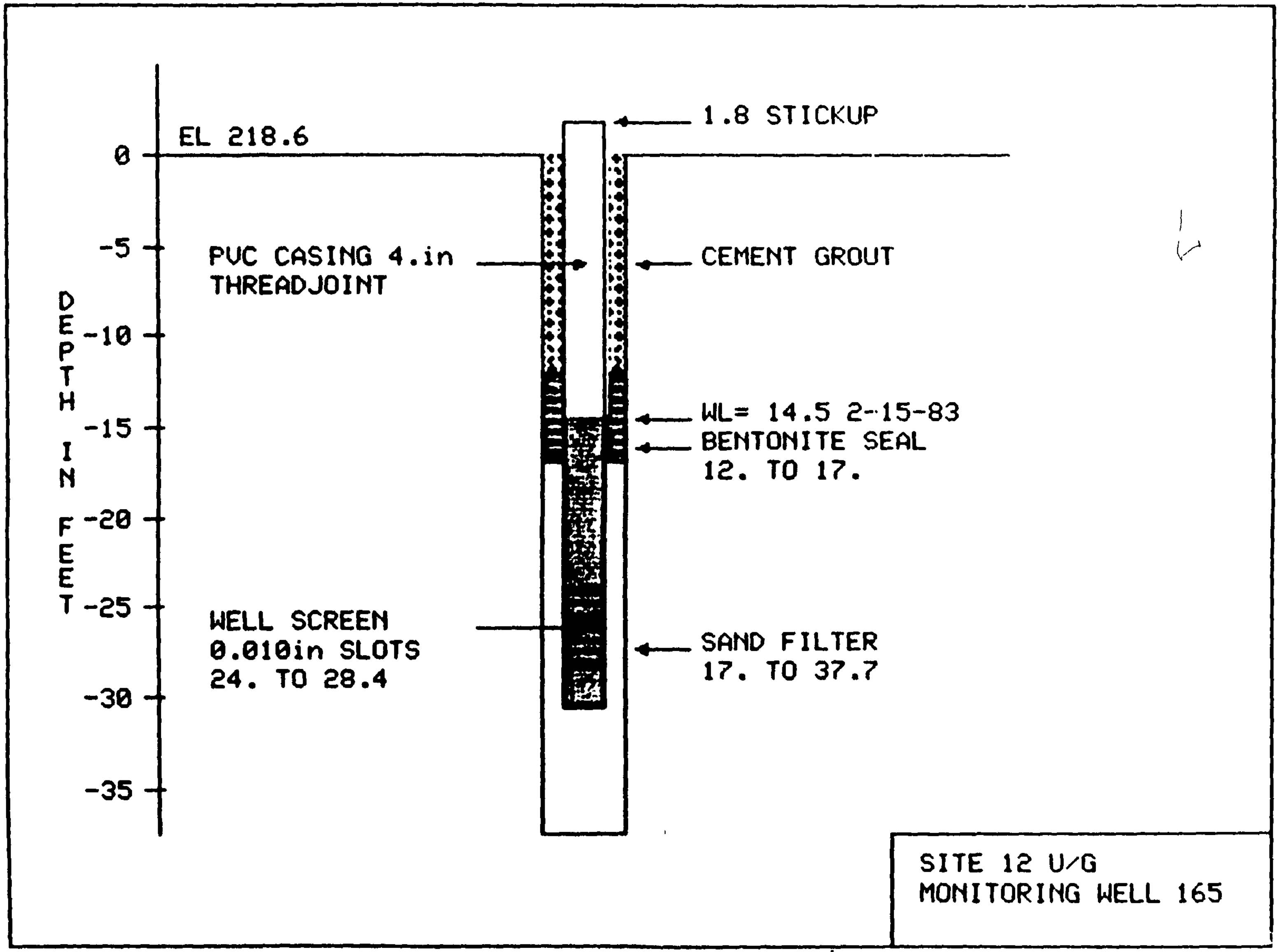
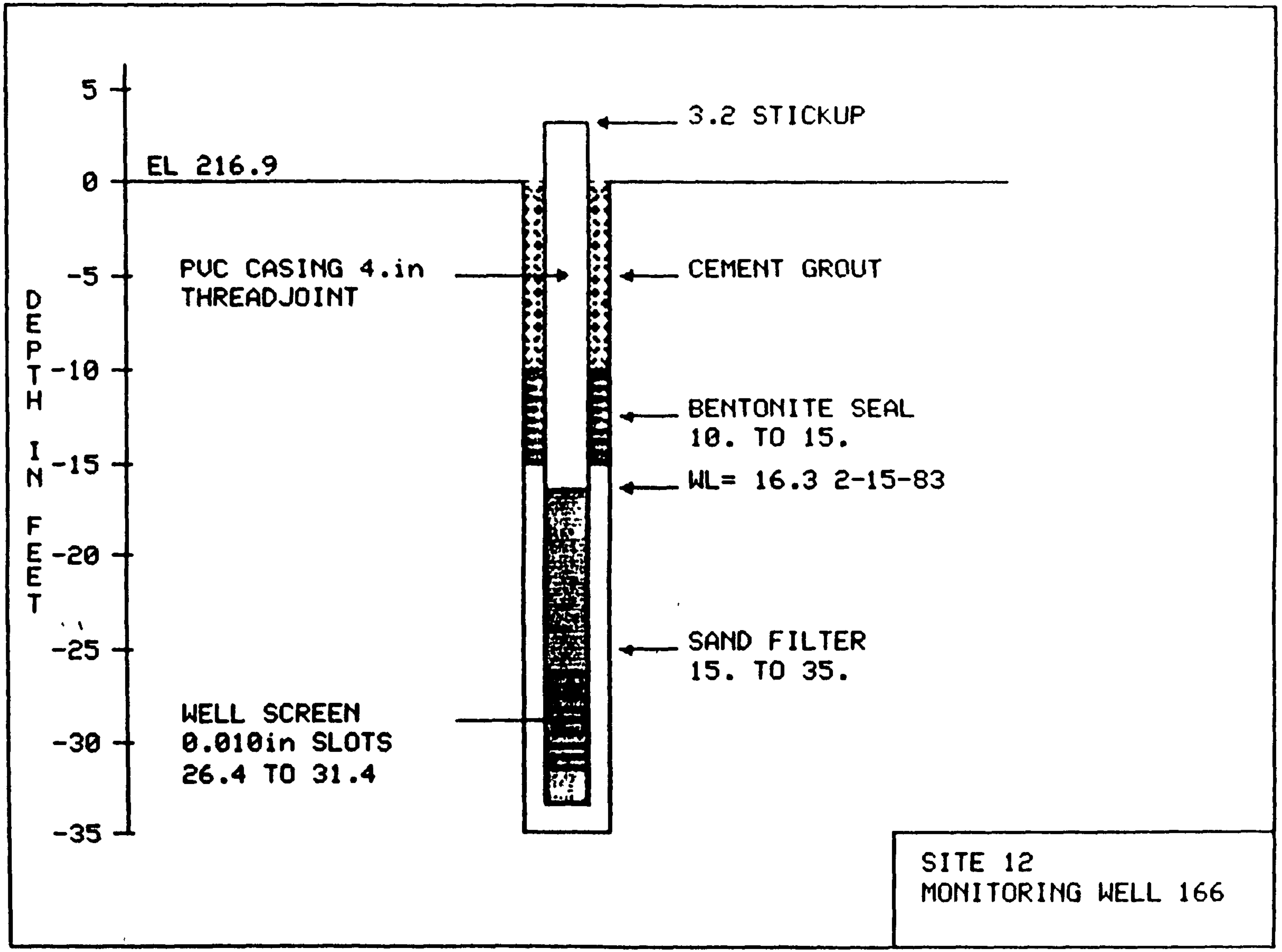

1.8 STICKUP
EL 218.6
0
-5
-10
-15
-20
-25
-30
-35
DEPTH IN FEET
PVC CASING 4.in
THREADJOINT
CEMENT GROUT
WL= 14.5 2-15-83
BENTONITE SEAL
12. TO 17.
WELL SCREEN
0.010in SLOTS
24. TO 28.4
SAND FILTER
17. TO 37.7
SITE 12 U/G
MONITORING WELL 165

TABLE 12-3
MUSTARD BURN PITS
SITE 12 - SWMU 10

WELL 165 - Upgradient Well

DATE	ARSENIC µg/l	CADMIUM µg/l	LEAD µg/l	SELENIUM µg/l	ZINC µg/l	BARIUM µg/l	CHROMIUM µg/l	MERCURY µg/l	SILVER µg/l	TOTAL ORGANIC CARBON mg/l	TOTAL ORGANIC HALOGEN mg/l	pH	AVERAGE LAB CONDUCTIVITY µmhos/cm
NIPDWR	50	10	50	10	5000+	1000	50	2	50			6.5-8.5+	
Mean Background	1	0.1	3	0.2	320	150	20	0.03	0.009	18.1	0.20	6.5	541
03/29/83	10	<5	<10	<5		300	30	<0.2	<10	50	.03	6.80	558
06/21/83	<10	<5	<10	<5		200	<10	<0.2	<10	57.5	.05	6.80	1155
09/27/83	<10	<5	<5	<5		500	<25	<0.2	<25	9.25	.055	7.00	524
04/24/84	<10	1	3	<5	22	<300	<1	<0.2	<10	6.0	<.01	6.60	1035
03/18/85	<10	<1	<5	<5	98	358	7	<0.2	<25			7.20	898
08/13/85	<10	<1	7	<5	123	444	2	<0.2	<25			6.7	1098
04/07/86	26	<1	<5	<5	46	<300	<10	<0.2	<25			6.7	1174
03/23/87	11	<1	<1	<1	90	240	<20	0.4	<20			6.6	1015

NIPDWR - Primary Drinking Water Standards
+Secondary Drinking Water Standards 40 CFR §143.3



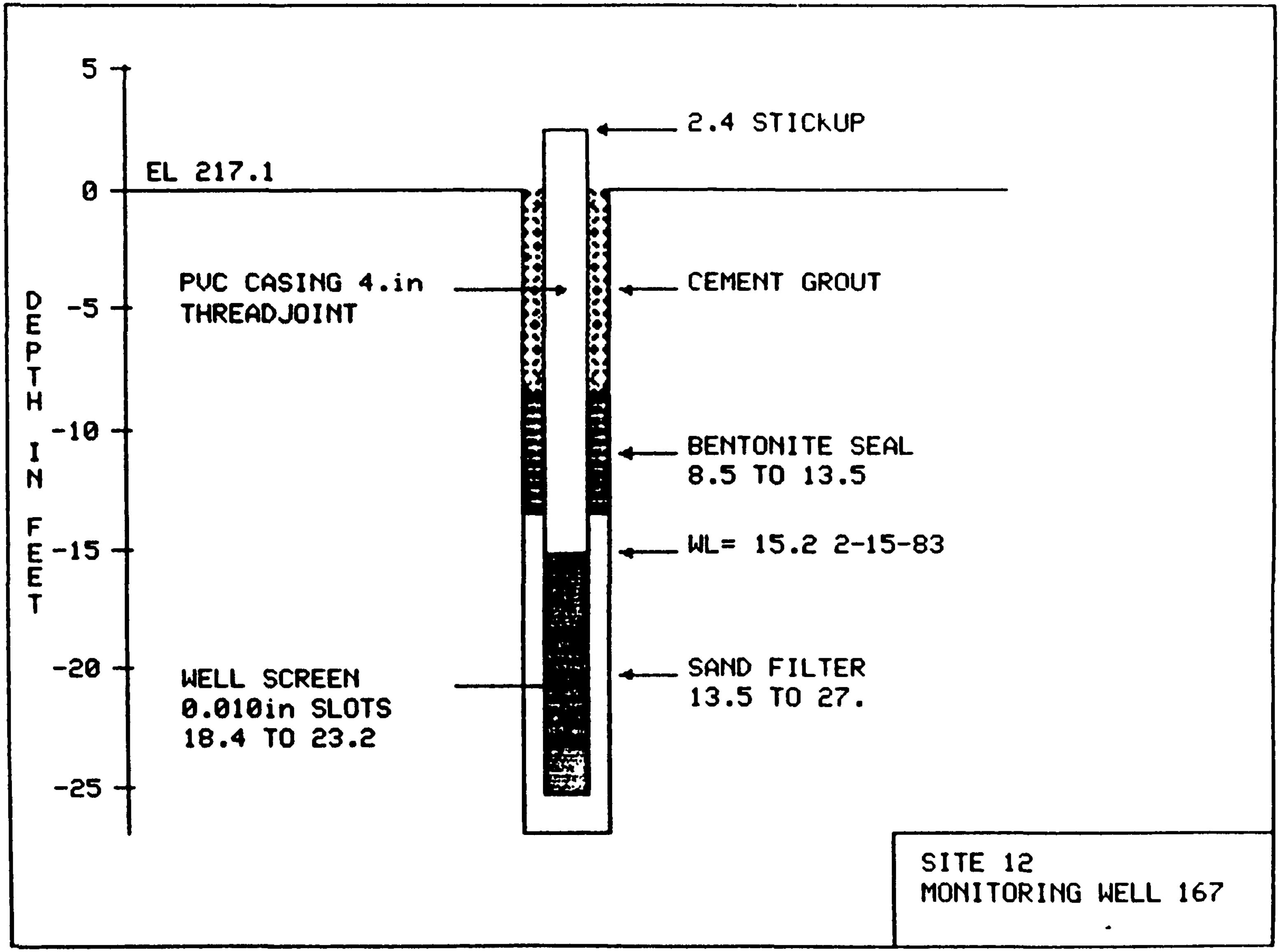
3.2 STICKUP
EL 216.9
PVC CASING 4.in
THREADJOINT
CEMENT GROUT
BENTONITE SEAL
10. TO 15.
WL= 16.3 2-15-83
SAND FILTER
15. TO 35.
WELL SCREEN
0.010in SLOTS
26.4 TO 31.4
DEPTH IN FEET
5
0
-5
-10
-15
-20
-25
-30
-35
SITE 12
MONITORING WELL 166

TABLE 12-4
MUSTARD BURN PITS
SITE 12 - SWMU 10

WELL 166 - Downgradient Well

DATE	ARSENIC µg/l	CADMIUM µg/l	LEAD µg/l	SELENIUM µg/l	ZINC µg/l	BARIUM µg/l	CHROMIUM µg/l	MERCURY µg/l	SILVER µg/l	TOTAL ORGANIC CARBON mg/l	TOTAL ORGANIC HALOGEN mg/l	pH	AVERAGE LAB CONDUCTIVITY µmhos/cm
NIPDWR	50	10	50	10	5000+	1000	50	2	50			6.5-8.5+	
Mean Back-ground	1	0.1	3	0.2	320	150	20	0.03	0.009	18.1	0.20	6.5	541
03/29/83	<10	<5	<10	<5		400	10	<0.2	<10	78.5	0.04	6.90	718
06/21/83	<10	<5	<10	<5		400	<10	<0.2	<10	69.5	0.05	6.80	1235
09/28/83	<10	<5	<5	<5		800	<25	<0.2	<25	6.4	0.03	7.10	524
03/18/85	<10	<1	<5	<5	291	784	3	<0.2	<25			7.10	1050
08/13/85	<10	<1	<5	<5	123	776	1	<0.2	<25			6.80	1175
04/07/86	15	<1	<5	<5	24	704	<10	<0.2	<25			7.00	1388
03/23/87	<5	<1	<1	<1	240	560	<20	<0.2	<20			6.50	1495

NIPDWR-National Interim Primary Drinking Water Regulations
+Secondary Drinking Water Standards 40 CFR §143.3



SITE 12
MONITORING WELL 167

TABLE 12-5
MUSTARD BURN PITS
SITE 12 - SWMU 10

WELL 167 - Downgradient Well

DATE	ARSENIC µg/l	CADMIUM µg/l	LEAD µg/l	SELENIUM µg/l	ZINC µg/l	BARIUM µg/l	CHROMIUM µg/l	MERCURY µg/l	SILVER µg/l	TOTAL ORGANIC CARBON mg/l	TOTAL ORGANIC HALOGEN mg/l	pH	AVERAGE LAB CONDUCTIVITY µmhos/cm
NIPDWR	50	10	50	10	5000[+]	1000	50	2	50			6.5-8.5[+]	
Mean Back-ground	1	0.1	3	0.2	320	150	20	0.03	0.009	18.1	0.20	6.5	541
03/29/83	<10	<5	<10	<5		300	10	<0.2	<10	55	0.04	7.10	602
06/21/83	<10	<5	<10	<5		400	<10	<0.2	<10	45.5	0.09	7.30	980
09/28/83	<10	<5	<5	<5		500	<25	<0.2	<25	5.2	0.02	7.30	431
04/24/84	<10	1	<1	<5	211	<300	<1	<0.2	<10	3.8	<0.01	7.00	850
03/18/85	<10	<1	<5	<5	225	678	1	<0.2	<25			7.90	778
08/13/85	<10	<1	8	<5	487	539	1	<0.2	<25			7.00	875
07/28/86	16	<1	15	18		454	<10	<0.2	<25			7.28	888
03/23/87	<5	<1	16	<1	350	450	<20	<0.2	<20			6.90	878

NIPDWR-National Interim Primary Drinking Water Regulations
[+]Secondary Drinking Water Standards 40 CFR §143.3

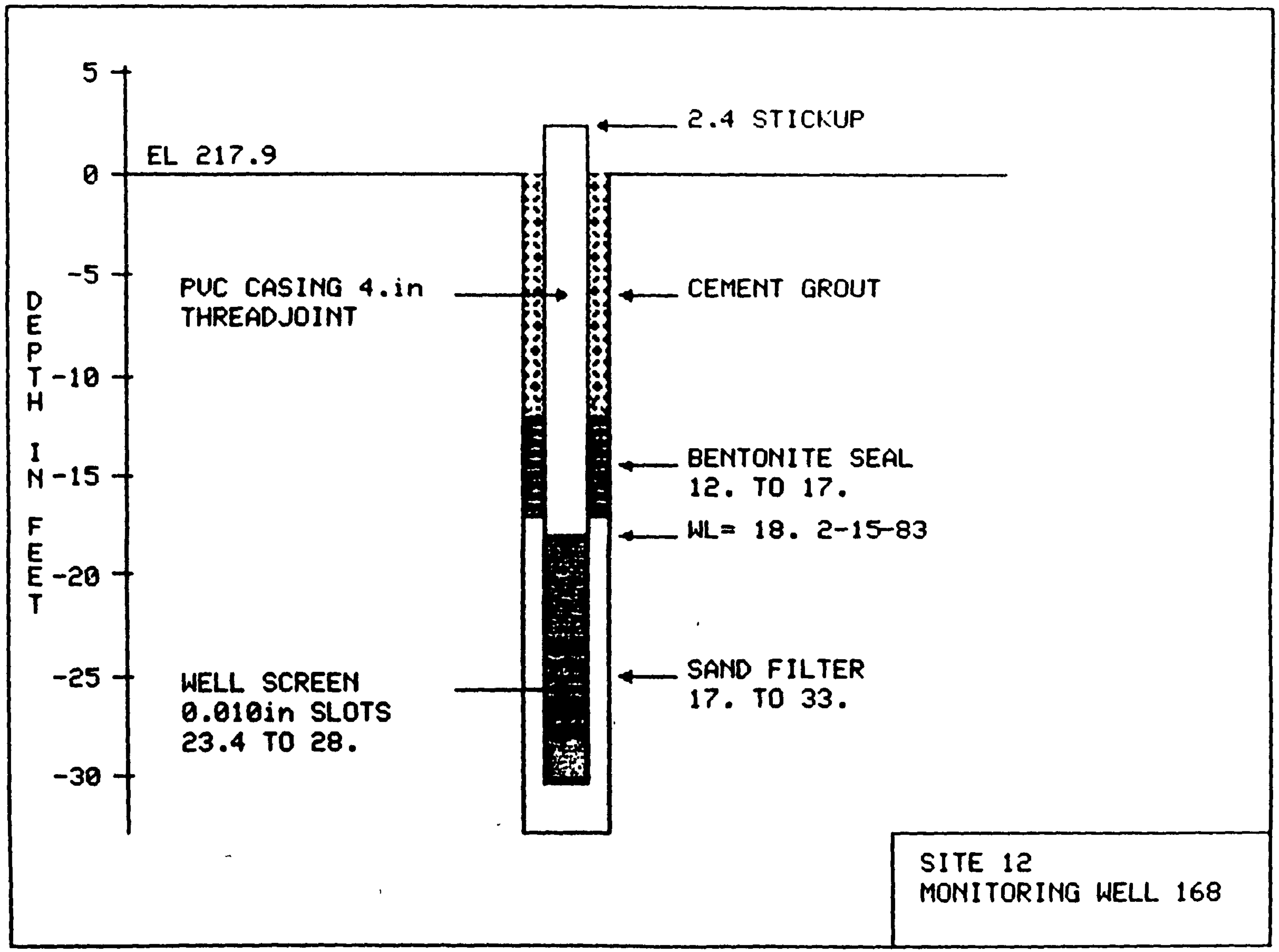

5
0
-5
-10
-15
-20
-25
-30
DEPTH IN FEET
EL 217.9
2.4 STICKUP
PVC CASING 4.in
THREADJOINT
CEMENT GROUT
BENTONITE SEAL
12. TO 17.
WL= 18. 2-15-83
SAND FILTER
17. TO 33.
WELL SCREEN
0.010in SLOTS
23.4 TO 28.
SITE 12
MONITORING WELL 168

TABLE 12-6
MUSTARD BURN PITS
SITE 12 - SWMU 10

WELL 168 - Downgradient Well

DATE	ARSENIC µg/l	CADMIUM µg/l	LEAD µg/l	SELENIUM µg/l	ZINC µg/l	BARIUM µg/l	CHROMIUM µg/l	MERCURY µg/l	SILVER µg/l	TOTAL ORGANIC CARBON mg/l	TOTAL ORGANIC HALOGEN mg/l	pH	AVERAGE LAB CONDUCTIVITY µmhos/cm
NIPDWR	50	10	50	10	5000[+]	1000	50	2	50			6.5-8.8[+]	
Mean Back-ground	1	0.1	3	0.2	320	150	20	0.03	0.009	18.1	0.20	6.5	541
03/29/83	<10	<5	<10	<5		<100	<10	<0.2	<10	43	0.05	7.10	562
06/21/83	<10	<5	<10	<5		300	<10	<0.2	<10	30.5	0.06	7.20	710
09/28/83	<10	<5	<5	<5		400	<25	<0.2	<25	6.8	0.02	7.30	355
04/24/84	<10	<1	1	<5	36	<300	<1	<0.2	<10	3.5	<.01	7.10	692
03/18/85	<10	<1	<5	<5	180	572	<1	<0.2	<25			7.40	598
08/13/85	<10	<1	<5	<5	275	397	1	<0.2	<25			7.00	618
04/07/86	<10	<1	<5	<5	238	315	<10	<0.2	<25			7.05	600
03/23/87	<5	<1	<1	<1	210	330	<20	<0.2	<20			6.70	675

NIPDWR-National Interim Primary Drinking Water Regulations
[+]Secondary Drinking Water Standards 40 CFR §143.3

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ICF TECHNOLOGY INCORPORATED

DOCUMENT TRANSMITTAL RECORD

TO: EPA Region 6 WAM or Malcolm Bender

FROM: Debra Pandak, ICF Technology Inc

REF: ARCS Contract No. 68-W9-0025
WA 35-6JZZ

The report for Pine Bluff Arsenal (SIP) was delivered to EPA on October 19, 1993 by ICF Technology Inc.

Please sign or inital receipt of document below:

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